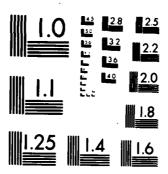
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AIRFRAME RDT&E COST ESTIMATING:
A JUSTIFICATION FOR AND DEVELOPMENT
OF UNIQUE COST ESTIMATING RELATIONSHIPS
ACCORDING TO AIRCRAFT TYPE

Charles L. Beck, Jr., Captain, USAF Dennis L. Pfeil, Major, USAF

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Charles L. Beck, Jr., Captain, USAF Dennis L. Pfeil, Major, USAF			
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School of Systems and Logistics Air Force Institute of Technology, WP	AFB, OH	10. PROGRAM ELEMENT, PROJECT, TA APEA A WORK UNIT NUMBERS	
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Department of Communication and Hu	manities	September 1982	
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Airframe RDT&E costs are invariably predicted by utilizing one general cost estimating relationship (CER) regardless of aircraft type (fighter, attack, or bomber/cargo). This practice results in inconsistent and often very significant inaccuracies in predicting weapon system development costs which may affect subsequent program funding. This thesis examines the utility of a unique CER for each aircraft type to be used for estimating airframe development costs. The methodology consisted of factor analysis and step-wise multiple regression analysis. Based on the results, the authors concluded that the unique CERs are consistently and significantly more accurate when estimating airframe RDT&E costs than the general CERs developed by former studies. The results of this study should be applicable to those organizations dealing with the procurement of aircraft airframes.



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## AIRFRAME RDT&E COST ESTIMATING: A JUSTIFICATION FOR AND DEVELOPMENT OF UNIQUE COST ESTIMATING RELATIONSHIPS ACCORDING TO AIRCRAFT TYPE

#### A Thesis

Presented to the Faculty of the School of Systems and Logistics of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the Requirements for the Degree of Master in Science in Logistics Management

Ву

Charles L. Beck, Jr., BS Captain, USAF

Dennis L. Pfeil, BA Major, USAF

September 1982

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Major Dennis L. Pfeil

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MASTER OF SCIENCE IN LOGISTICS MANAGEMENT

DATE: 29 September 1982

COMMITTEE CHAIRMAN

#### **ACKNOWLEDGEMENTS**

We are grateful to Lieutenant Colonel Ted Novak, Lieutenant Commander Joe Stewart, and Mr Roland Kankey for their helpful advice and guidance with this thesis. We are particularly appreciative of their willingness to allow us freedom of management while providing valuable direction. Several other faculty members provided valuable assistance for which we are extremely thankful.

A special note of thanks goes to our families for their support and understanding under often trying conditions. We sincerely congratulate and thank JoWilla Beck for her patience as a typist and performance of abovery well done!

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#### CHAPTER I

#### INTRODUCTION

The analysis of weapon system life cycle costs (LCC) is an integral part of the decision making process regarding Air Force systems acquisitions (10:1). Life cycle costs, when related to USAF aircraft, consist of all costs associated with the Research, Development, Test & Evaluation (RDT&E), Production, and Operation & Support (O&S) phases (10:11). Defense procurements in 1979 totaled almost \$35 billion (3:12). Of that amount, approximately 45%, or almost \$16 billion were expended on RDT&E programs (3:102). The RDT&E costs associated with the F-16 alone amounted to over \$741 million over a six year period (6).

Although the use of life cycle cost analysis has been widespread it is not yet a finished and fully effective management tool. Many acquisition managers lack confidence in current LCC analysis techniques and are uncertain as to their efficiency. This uncertainty becomes significant when LCC analysis is used as an aid in economic tradeoff evaluations and in funding decisions demanding reliable, internally consistent estimates of absolute cost (10:1).

Cost estimating capability is only as accurate as the information on which the estimates are based. On some large, complex development programs, the degree of accuracy surrounding an estimate may be -10% to +100% or more. Decision makers must be informed about the degree of accuracy so that they will not erroneously assume that an estimate is accurate to within plus or minus 10% [2:154].

Numerous cost models have been developed for each phase of a system's life cycle. However, the models pertaining to the RDT&E phase appear to be limited in their ability to accurately predict weapon system development costs. This thesis focuses on a shortcoming present in all cost models that have been examined by this thesis team. Most models place heavy emphasis on production and O&S phase costs, by using parameters identified through research of these two phases, to form the basis for the models' cost estimating relationships (CERs). When applied to aircraft, the research results in parametric equations unique to each aircraft type (fighter, attack, and cargo/bomber) for the production and O&S costs elements (i.e., the equation developed to estimate production cost elements for the F-15 would be different from that of the C-141). However, separate parametric equations based on aircraft type are not utilized to predict RDT&E costs. All existing models establish one CER equation that is used regardless of type aircraft for RDT&E cost estimates. That is, the models establish one algorithm for RDT&E that is used regardless of whether the aircraft is a fighter, attack, or cargo/bomber. Chapter II will examine and discuss selected algorithms in more detail.

#### Problem Statement

Airframe RDT&E costs are currently estimated by using one general CER in all existing models rather than a unique CER for each aircraft type. This practice may have substantial impact on the accuracy of RDT&E cost estimates and subsequent program funding.

#### Justification for Research

In the purview of acquisition managers, cost estimating techniques must be refined to more accurately predict weapon system costs. In this light, valid cost estimating techniques should be developed which reflect the unique cost characteristics for each aircraft type throughout each phase of the acquisition process. Common sense dictates that RDT&E cost equation for a small supersonic fighter aircraft, such as the F-16, should be different from the RDT&E cost equations associated with a large subsonic aircraft such as the C-5. Any attempt to estimate RDT&E costs for such dissimilar aircraft types using common and general CERs is likely to result in less accurate cost projections than could be obtained by using separate CERs for each aircraft type. As an example, a cost model developed by Grumman Corporation projected RDT&E costs with general CERs that had been developed using fighter, attack, and cargo airframe cost elements. The resulting estimates for airframes ranged from a 30% underestimate to a 20% overestimate (13:208).

The base model referred to throughout this thesis is the model initially developed by Grumman in 1976, as revised in 1980. This model is one of the most recently developed cost estimating tools and is based on data pertaining only to fairly recent procurements. The data base is available and has been verified for accuracy. Additionally, the Grumman model is useful for performing cost/design and performance trade-offs due to the airframe characteristics identified and included in the model as cost drivers. The Grumman model is reviewed in Chapter II of this thesis.

#### Purpose and Objective

This thesis is restricted to the development of algorithms that are structured for a single design type aircraft. An attempt to develop separate CERs by aircraft type for airframe RDT&E cost elements is based on logical cause and effect relationships between the dependent variables and independent variables. This logical relationship is supported by factor analysis and multiple regression analysis. The CERs that are developed are statistically compared with the base model in order to determine relative accuracy in predicting RDT&E costs.

#### Research Hypotheses

- 1) The initial research hypothesis proposed by this thesis is that a unique CER exists for each type of airframe (fighter, attack, cargo) for the RDT&E phase of the acquisition process.
- 2) The second hypothesis is that the unique CERs more accurately predict airframe RDT&E costs.

#### Scope

An attempt is made to develop CERs that pertain only to RDT&E airframe development costs. The CERs are developed based on data gathered on several fighter, attack and cargo aircraft, all in the "A" configuration. The analysis is limited to fighter, attack and cargo because of the limited and insufficient data available on all other aircraft configurations (trainer, bomber, etc.).

#### General Research Plan

This thesis research effort logically gathers data on all three types of airframe structures, groups the airframes by means of correlation of

characteristics through the use of factor analysis, and develops an algorithm for the grouped data by using multiple regression analysis. The resulting CERs are then compared to CERs of the base model by using statistical tests of significance and measures of accuracy.

Support of the thesis hypotheses indicates that greater accuracy should be achieved by using specialized CERs. Improved cost estimates allow improved budgeting by DoD and Congress, and decrease the chances of cost overruns which may be viewed as politically unacceptable and ultimately may lead to cancellation of the program.

#### CHAPTER II

#### LITERATURE REVIEW

#### Introduction

A number of tools and techniques have been developed for use in estimating different categories of weapon system costs. For many years estimates of aircraft airframe costs were based primarily on weight. However, cost estimators have continuously searched for other aircraft characteristics that (1) will, in combination with weight, provide consistently accurate estimates, (2) are logically related to cost, and (3) can easily be determined prior to actual design and development, thus allowing for trade offs between cost and performance/physical characteristics (8:1).

Three of the most popular methods currently used for cost estimating are the analogy method, the engineered method, and the parametric method. The choice of which cost estimating method should be used is often governed by the time available for the estimating effort, the degree of system definition at the time of the analysis, the kind and amount of input data available, and the level of detail required (15:7.3).

Each of the three methods is described in the following paragraphs.

#### Analogy Method

When applying this method, estimated costs of the new items are derived from past costs of items that are at least similar in all important respects. The reasonableness of the quotations or prior prices must be

established and an allowance made, through use of adjustment factors, for all differences between the proposed item and the past items used for comparison. Data used for making analogous estimates is normally taken from a library of catalogs and historical records of recent procurements, and includes information on the specification, schedule, and the contracting environment in which the item was procured (7:4, 5).

The need to rely on past procurements of similar items, based on the analyst's judgement, is one disadvantage to using the analogy method (15:7.5). A second disadvantage is that the adjustment factors used to account for differences are completely subjective. They are based solely on the analyst's judgement regarding the magnitude of the differences between the proposed item and the past items used for comparison. Additionally, analogy models tend to have limited usefulness with respect to design trade off applications since they ordinarily compute costs as a function of parameters such as mean time between failures and maintenance man-hours per flying hour. They do not relate costs directly to performance and design parameters and, therefore, cannot be used early in the conceptual phase of development when trade offs relating to performance/design parameters are usually made (1:24).

#### Engineered Cost Method

Estimations made by this method are based on an extensive know-ledge of the system characteristics, requiring the cost analyst to have a detailed knowledge of the system, the production processes, and the production organization. A total project cost estimate is obtained by consolidating estimates from the various separate work segments (15:7.5).

If detailed cost data is available, the engineered cost method is preferred for making cost estimations (15:7.6). However, the required cost detail is not usually available early in the development process, particularly for DoD procurements, making this approach difficult to apply (15:7.5). Commonly, by the time detailed information is at hand many decisions have already been made and the choice among various initial alternative systems has been reduced to only a few (11:5-8). In addition, the engineered cost method is generally more costly and time consuming than other cost estimating techniques. One major defense firm has indicated that use of this method for estimating only airframe costs requires more than 4,000 separate estimates (15:7.6).

#### Parametric Cost Estimating

When applying parametric cost estimating techniques, the cost of a new item is based on physical and performance characteristics as well as costs of previously procured items (7:6). Through curve-fitting techniques, system cost is related to a combination of system parameters, such as physical dimensions, weight, maximum speed, etc. The relationships established, in the form of mathematical equations, are referred to as cost estimating relationships (CERs), which can be quite simple or very complex. Normally, the dependent variable in a CER is a cost element, such as engineering labor hours, while the independent variables are system parameters. CERs have been developed to reflect RDT&E, production, and/or operating and support (O&S) costs. They can be applied to individual segments of these costs or can reflect a composite of them all which results in a total system cost (11:5-6).

If detailed cost data is not available, parametric cost estimating is preferred over other methods for at least three reasons: (1) CERs can be developed and used early in the preliminary design stages of RDT&E to study the effects of varying parameters on system cost, thus allowing cost comparisions of different alternative designs; (2) the relationships developed can be used to obtain preliminary cost estimates before the details of design or O&S concepts are certain; (3) they require less input data than engineered models and can be more easily used for sensitivity or parametric analysis (1:26).

DoD is currently emphasizing the utilization of design to cost (DTC) techniques in all major weapon system acquisition programs. DTC calls for establishing weapon system cost parameters that can be translated into "design to" requirements. All R&D, production, and operating costs are directed to be principal design considerations. The focus is on practical trade offs weighing costs against system capability and program schedule requirements (16:2).

Of the three cost estimating techniques previously described, parametric cost estimating best lends itself to the implementation of DTC and its inherent trade offs between cost and physical/performance characteristics of a weapon system. In order for DTC to be effectively applied, it must be utilized early and throughout a development program. Early utilization of the engineered cost method is usually not possible due to the requirement for detailed cost data not yet available. The analogy method is also inappropriate for DTC application since the analogy models do not normally relate costs directly to performance and design parameters.

The remainder of this chapter reviews studies designed to develop parametric cost estimating models with emphasis on their application to airframe RDT&E costs.

#### Model Review

#### PRC 547-A, April 1967

One of the early attempts at estimating airframe development and production costs was undertaken by the Planning Research Corporation. The primary objective of the study was to develop suitable techniques for use in cost-effectiveness studies and evaluation of contractor proposals (14:vii).

The model, developed by use of multiple stepwise regression, consists of three distinct cost elements: direct manufacturing labor, manufacturing materials, and engineering and tooling (combined as one element). The sample included forty-one aircraft, both propeller driven and turbojet, dating as far back as 1940. The aircraft characteristics used as independent variables were speed, weight, and functions of these (e.g., speed squared) (14:II-2).

The cost estimating methodology involved deriving separate estimating equations for each cost element at production units 10, 30, 100, and 300. These estimates are then used to derive cost-quantity curves to enable cost estimation for any desired quantity (14:III-1). To illustrate, in order to estimate the cost of manufacturing labor for aircraft unit 1, four separate estimating equations were developed (one each for quantities 10, 30, 100, and 300). The estimated cost for manufacturing labor (expressed in average cost per airframe) is then plotted on logarithmic graph paper. A "best-fit" straight line is then drawn through the four points and extended back to the vertical axis to obtain an estimate of unit 1 (prototype) manufacturing labor

costs. Thus, twelve equations were developed, four for each cost element, to derive three cost estimating curves.

The coefficients of determination (R<sup>2</sup>) for the CERs derived for airframe unit 10 are listed below for each cost element:

Cost Element	$\mathbb{R}^2$
Manufacturing Direct Labor	.8172
Manufacturing Materials	.8354
Tooling and Engineering	.8028

Although the R<sup>2</sup> values appear significant it should be remembered that these values apply only to the CERs developed for estimating the costs of airframe unit 10. It should not be assumed that the same coefficient of determination, an indication of regression line fit, is applicable to estimates made of airframe units other than 10, such as one or two, which might be prototype airframes. The study does not attempt to develop separate cost equations for prototype and production costs. Instead, the curve-fitting technique previously described results in "backing-in" to the cost of the early airframe units, irregardless of whether the units are prototype or production airframes.

One of the difficulties inherent in this study is the heterogeneity of the sample used to derive the CERs. There is no attempt to stratify the data according to aircraft type (cargo, fighter, attack, etc). The physical and performance characteristics of the sample aircraft, as well as the period of their development and production, differ widely.

#### Rand Studies

A number of studies relating to aircraft cost estimating relationships have been performed by the Rand Corporation. Two of the Rand studies which discuss airframe development costs are summarized in the following paragraphs.

R-761-PR, December 1971. This report presents separate CERs for the following cost elements pertaining to airframes: engineering, development support, flight test operations, tooling, manufacturing labor, manufacturing material, and quality control, as well as a separate set of equations for prototype development. The CERs are expressed as exponential equations derived by multiple regression techniques which relate costs or man-hours to aircraft physical and performance characteristics (9:1).

The equations were derived from historical data on twenty-nine post-World War II military aircraft, including cargo, tanker, fighter, bomber, and training aircraft, that were produced in quantity for operational military use. Most of the aircraft are turbojet, with a few propeller types included, and range in speed from low subsonic to Mach 2.2 (9:1). The majority of the cost and hour data used as dependent variables were obtained from the contractor. The aircraft physical and performance parameters (independent variables) found to be most useful for explaining variations in cost and man-hours are quantity, AMPR weight, and maximum airspeed at optimum altitude.

Of the twenty-nine aircraft included in the data base, fourteen were begun as prototype programs, with the remainder procured more or less under the concurrency method. The equations derived for prototype development (which approximates RDT&E) are:

Prototype Engineering (Total hours)

$$E_p = 8.634 \text{ A} \cdot .576 \text{ S} \cdot .856 \text{ Q}_p \cdot .960$$

$$R^2 \text{ (unadjusted)} = .65$$

Prototype Development Support (Total 1970 dollars)

$$D_p = .065 \text{ A} \cdot ^{366} \text{ S}^{2.267} Q_p^{.485}$$

 $R^2$  (unadjusted) = .88

Prototype Tooling (Total hours)

$$T_p = 57.335 \text{ A} \cdot ^{.466} \text{ S} \cdot ^{.633} Q_p \cdot ^{.482}$$

$$R^2(\text{unadjusted}) = .60$$

Prototype Manufacturing (Total hours)

$$L_p = .3019 \text{ A}^{1.118} \text{ S}^{.410} Q_p^{1.366}$$

$$R^2 \text{ (unadjusted)} = .98$$

Prototype Material (Total 1970 dollars)

$$M_p = 1.5 \text{ A}^{.585} \text{ S}^{1.213} Q_p^{.622}$$

$$R^2 \text{ (unadjusted)} = .64$$

Where A = AMPR weight (lb),

S = maximum speed (knots) at best altitude,

Q<sub>n</sub> = protoype quantity (9:29)

Separate relationships were not derived for flight test costs or quality control costs relating to the RDT&E phase in this report. Additionally, CERs for manufacturing cost data were developed from the entire data set, including the concurrent procurements, and were not derived for the sole purpose of estimating prototype airframe costs.

This model received criticism from its users because of two perceived shortcomings: (1) the only two major explanatory variables were weight and speed; and (2) all aircraft were lumped together rather than treated as classes (e.g., fighter, attack, cargo, etc.). As a result of this criticism, Rand initiated a study in 1976 to produce a new estimating model.

R-1693-1-PA&E, February 1976. This study was sponsored by the Office of the Assistant Secretary of Defense as part of a research program focused on improved methods of estimating the development, procurement, and operating costs of new weapon systems. Generalized equations are presented for estimating development and production costs of aircraft, again primarily on the basis of weight and speed. A separate equation is provided for estimating prototype aircraft development costs.

Initially, 16 aircraft (including such antiquities as the B-47, F3D, F-84, F-86, and F-89) were used to derive prototype airframe estimating equations for each major cost element. The results were very poor statistically and it appeared that the equations were not reliable (8:50).

The six oldest aircraft were deleted from the sample and a second attempt was made at deriving a reliable estimating equation for each major cost element. As shown in the following table, the results were again statistically poor (8:50).

Independent Variable

		Weight		Speed		Quantity	
Cost Element	$R^2$	T-Ratio	LS*	T-Ratio	LS	T-Ratio	LS
Engineering Hours	.166	1.027	.66	.118	.09		
Tooling Hours	. 404	1.561	.84	334	.25		
Manufacturing Hours	. 590	3.175	.98			.62	.45
Manufacturing Material	.356	.793	.55			1.914	.90
Flight-test Cost	.189	.829	. 57	1.274	.76		
	*Leve	l of signifi	cance				

An equation was then derived by combining the individual cost elements and dealing with total prototype program cost. The following equation was obtained:

$$TC_p = 1115.4 \text{ (wt)} .35 \text{ (N)} .99$$

$$R^2 = .75$$

$$F = 10.4$$

Where TC<sub>p</sub> = total prototype program cost (1973 \$)

wt = airframe unit weight (lb.)

N = number of prototypes

The problem with estimating prototype development costs, according to the report, is that there is little homogeneity among prototype programs (8:49). The samples used in this study were not limited to aircraft developed under a fly-before-buy concept. According to the authors,

The problem is one of definition and of sample size. If we define a prototype program as one in which the first lot consists of 3 aircraft or less, we clearly will include programs in which preproduction costs are incurred in the first lot. If we define a prototype program as one in which no thought whatsoever is given to production considerations, our sample will dwindle to a very few aircraft...[3:49].

Although the equation developed to estimate total prototype program cost appears to approximate the cost of current prototype programs fairly well, "...this is clearly an area in which further research is required [8:5] ".

Thus, no attempt was made to group the aircraft by type (attack, fighters, cargo, etc) when developing the prototype airframe cost equations. However, the study did explore stratification when developing CERs for cost elements other than prototype program costs. This attempt at grouping by type did not yield satisfactory statistical results.

#### FR-103-USN, September 1973

This report was prepared by J. Watson Noah Associates, Inc., for the Chief of Naval Operations, USN. The contract was originally awarded to examine aircraft R&D costs, and to derive CERs for their estimation. However, it became apparent very early in the effort that historical R&D costs would be very difficult to isolate with a significant degree of certainty. It was therefore decided that both R&D and production costs should be examined (12:iii).

The data base consisted of historical costs and characteristics of thirty-five airframes. Airframe costs were aggregated to include engineering, tooling and manufacturing labor, and materials costs (12:v). Although no attempt was made to develop separate equations for airframe RDT&E costs, the costs were divided into non-recurring and recurring costs. The non-recurring costs include much of what is commonly referred to as RDT&E costs and encompass the following costs:

 Preliminary design effort for translating concepts and requirements into specifications as well as for modifications of existing systems.

- Design engineering entailing the specification and preparation of the original set of detailed drawings for new systems as well as for major modifications of existing systems.
- Tests, test spares, and mock ups regardless of when they occur during the program life.
- 4. All tooling, manufacturing, and procurement costs specifically incurred while performing development or tests, except for the manufacture of complete units during the development program.
- The initial tools and all duplicate tools produced to permit the designed production rate for a program.
- 6. Training of service instructor personnel.
- 7. Initial technical data and manuals preparation (12:22, 23).

The CERs were developed by using multiple regression analysis and involved three major steps. First, a large number of variables in different combinations and functional forms were screened. An examination of conventional regression statistics (t-ratios, R<sup>2</sup>, standard errors of estimate, etc.) resulted in the elimination of several candidate variables. The preferred CER was then developed and a prediction interval was computed. As a form of validation, the equation was used to predict known costs (based on known characteristics) for one or more aircraft which had been temporarily excluded from the data base. Provided these results proved satisfactory, all of the observations were included in the CER development and the coefficients were re-estimated (12:44, 45).

Screening of candidate variables which might drive airframe non-recurring costs resulted in selection of the following:

S = Maximum speed

A = AMPR weight

R = Ratio of gross take off weight to AMPR weight

T = Technology index

C = Complexity dummy

The technology index variable was included to help explain the evolutionary materials changes which have occurred in airframe manufacturing. The complexity dummy was included because the CERs developed seriously underestimated the costs of four aircraft (F-102, F-106, B-58, and F-111). The use of the dummy variable was justified for these aircraft on the basis that each had a major mission or performance parameter which required significantly new and complex technology (12:47, 48).

Regression analysis resulted in the following CER for predicting non-recurring airframe costs (12.66):

$$Cost = -5.945 + .00663S + .05138T - 1.4071R + 6.74926 C$$

N = 32

 $R^2 = .847$ 

No attempt was made to develop separate CERs for each element of airframe non-recurring total costs. The study did not address grouping the aircraft by type; instead, the entire sample was used to develop each CER.

# Modular Life Cycle Cost Model (MLCCM), January 1980

This model was initially completed by Grumman Aerospace Corporation in October, 1976. The 1980 version is essentially the same except the model has been updated to include the most current data available.

The MLCCM is one of the most complete models yet developed with regard to the number and type of cost elements included. The model can be used to estimate airframe, engine, and avionics costs in the RDT&E, production, and O&S phases. Additionally, CERs are available for each aircraft type (fighter, attack, and cargo) for the production and O&S portions of this model.

The data base consists of cost elements and performance/physical characteristics from sixteen different aircraft, including such recent procurements as the F-15 and F-16. The cost elements used as dependent variables for the airframe RDT&E phase include: engineering labor, tooling labor, manufacturing and quality control (Q.C.) labor, manufacturing materials, and other direct charges. The following parameters are identified as major RDT&E airframe cost drivers and are used as the dependent variables: ultimate load factor (NZULT), maximum mach number (MAXMACH), total wetted area (TWTAREA), maximum takeoff gross weight (TOGWMAX), and number of prototype aircraft (PROTO) in the first buy (13:59-62). Both the dependent and independent variables are defined in Chapter 3 of this thesis.

Using regression analysis, the following CERs for airframe RDT&E costs were developed from a data base of 16 aircraft, including 8 fighters, 4 cargo, and 4 attack, all in the "A" configuration:

- 1. Total Engineering Labor (Manhours)
  - = 4.7561 (PROTO)<sup>-1271</sup> (NZULT)<sup>1.7218</sup> (MAXMACH)<sup>.39856</sup> (TWTAREA)<sup>1.2588</sup>
- 2. Total Tooling Labor (Manhours)
  - = 7.6038 (PROTO).32201 (NZULT) $^{1.2234}$  (MAXMACH).34498 (TWTAREA) $^{1.2137}$
- 3. Total Other Direct Changes (1975 \$)
  = (24.265 X 10<sup>-6</sup>) (PROTO).48268 (NZULT)<sup>1.7087</sup> (MAXMACH).5161
  (TWTAREA)<sup>1.2877</sup>
- 4. First Airframe, Manufacturing Materials (1975 \$)
  = (91.699 X 10<sup>-6</sup>) (PROTO). (NZULT) 1.0623 (MAXMACH). (TOGWMAX). 83621
- 5. First Airframe, Manufacturing and Q.C. Labor (1975 \$)
  = (672.54 X 10<sup>-6</sup>) (PROTO)<sup>-0846</sup> (NZULT)<sup>-88972</sup> (MAXMACH)<sup>-99829</sup>
  (TOGWMAX)<sup>-80029</sup>

(13:60, 61)

Grumman did not include values for the coefficient of determination (R<sup>2</sup>) in the report. Thus, it is difficult to determine how much of the variation in airframe RDT&E costs is explained by the parameters chosen as independent variables. Although the aircraft were stratified according to type for estimating the production and O&S costs, this was not done for the RDT&E phase. No rationale was presented that explained why the aircraft were not grouped by type when dealing with airframe RDT&E costs.

### Summary

Five studies designed to develop parametric cost estimating models which accurately predict airframe costs have been discussed. The models described were developed as long ago as 1967 and as recently as 1976, with updates as recent as 1980. Each of the models addresses airframe RDT&E costs in varying degrees of detail. All of the models were developed by use of a multiple stepwise regression using data bases of varying sizes, including aircraft of late and early vintage. For all but the Grumman MLCCM, the primary airframe RDT&E cost drivers were identified as being only speed and weight. None of the studies grouped the aircraft by type (fighter, cargo, attack) when developing the CERs pertaining to airframe RDT&E costs.

Cost estimating relationships are used not only to estimate cost elements, but also to make cost comparisons between various alternative system designs through sensitivity analysis. The identification and inclusion of a greater number of cost drivers as independent variables makes sensitivity analysis a more viable tool when choosing between design alternatives. For example, alternative A may call for a design ultimate load factor of 11 g's while alternative B may require an ultimate load factor of 9 g's. If ultimate load factor is indeed a major cost driver ( and thus an independent variable in the CER) then a cost performance trade-off analysis is possible using the CER. However, if the alternatives being compared do not have significant differences in weight (and weight and speed are the only independent variables) then a cost/performance trade-off analysis is not as easily performed.

The data base used in each study was very heterogenous in nature. That is, all aircraft are lumped together regardless of type as well as their period of development and production (the aircraft included in the Grumman MLCCM are more recent procurements). This heterogeneity makes the task of developing statistically strong CERs a difficult one.

This thesis focuses on grouping the aircraft by type when developing airframe RDT&E CERs. Chapter III contains the methodology of this thesis, including treatment of the data base, as well as the statistical methods used in the analysis.

### CHAPTER III

### **METHODOLOGY**

## Basic Methodology

This section constructs the logical flow of tasks that must be accomplished to test the stated hypotheses that 1) a unique CER exists for each type of aircraft airframe for the RDT&E phase of the acquisition process, and 2) the unique CERs provide more accurate cost estimates than a single generalized CER. The data was researched and collected for each type of aircraft, but only for the "A" configuration of that aircraft. Some cost models have included the "A" configuration plus subsequent configurations, which provides for a larger data base but also skews the analysis towards those aircraft with more than the basic configuration involved in the data base. This practice can also significantly underestimate development time in terms of engineering hours, labor hours, and other direct costs. The data was then analyzed with the aid of factor analysis. The characteristics shown to be correlated by factor analysis indicate whether the different types of aircraft airframes should be regressed together or separately 'o obtain the regression equation. Based upon the results of the factor analysis, the variables were regreed using a step-wise regression. Prior to the regression analysis the variable. rere converted to logarithms to provide the optimum log-linear relationship. The first series of regressions were run without considering the possibility of multi-collinearity, and the resulting F-value was compared to the base model.

regressions were accomplished considering multi-colineararity and attempted to remove it by using interaction terms or by eliminating those variables that are highly correlated to variables already in the regression equation. The results of this thesis methodology were evaluated by comparing the F values and beta coefficients of both the thesis generated model and the base model. Additionally, tests were performed on the beta coefficients to determine the significance for all resulting regressions and the base model. The analysis also developed confidence intervals for all beta coefficients to explore the possibility of the beta value existing ithin the same significant range of values developed by the different models.

## Data\_Base

Data are the key ingredients in any analysis. Accurate data are essential in the development of any model because the CERs are a direct reflection of the input parameters. The process of collecting data for cost analysis has been a difficult path to follow since most contracts fail to procure and document the detailed data necessary to conduct an analytical study. To further complicate the data collection, accounting practices differ from company to company, and even differ in the same company over a period of years. Additionally, strict definitions of terminology and methods of data collection must be used to ensure compatible data files.

The initial consideration for selection of data is that the data must logically be a determinate of what is estimated. Therefore, data used to estimate RDT&E costs for airframes should be factors of the structural complexity of aircraft design. Rand supports this logic somewhat in the selection of their model's independent variables, weight and speed, which

are indicators of the structural design features of the aircraft. Furthermore, independent structural design engineers indicate that any airframe cost (RDT&E or Production) is driven by the performance, size and weight of the particular aircraft (4, 6). Grumman supports this logic in the development of their own cost model by developing CERs that use performance, size and weight as leading design parameters in estimating airframe costs.

The number of prototypes logically reflect the number of RDT&E manhours spent on tooling and manufacturing, and the dollars spent on RDT&E manufacturing materials. Additionally, the number of prototypes logically indicate the level of manufacturing facilities utilized in the initial production of an airframe assembly (4, 6).

The data used to develop this thesis were collected by Air Force Flight Dynamics Laboratory (FXB) over a period of several months from various sources, and were cross-checked by FXB with other sources to ensure accuracy and authenticity. Additionally, the Aeronautical System Division Comptroller's office provided further assurance of the data accuracy. The data utilized is a subset of that provided to Grumman Areospace Corporation and therefore provides an excellent standard for comparing study findings. The subset used pertains solely to aircraft airframes, whereas the Grumman study entailed a study of the total aircraft including avionics, engines, and aircraft structure. The following are definitions of the design parameters utilized by Grumman and this thesis for development of airframe structural CERs.

### Independent Variables:

1. NZULT - Ultimate Load

Range: 3.75 to 12.75 (Number)

Factor that indicates the environment in which the airframe will operate; a reflection of g-level necessary for operational efficiency. A high number indicates g-loads encountered by fighters and attack aircraft; whereas, a low number indicates the environment that is encountered by a cargo aircraft.

2. MAXMACH - Maximum Mach

Range: 0.54 to 2.30 (Ratio)

Maxmach ratio relates the speed of the aircraft to the speed of sound. Additionally, it indicates increasing structural complexity which accompanies the high power levels and subsystem complexity necessary to achieve supersonic flight.

3. TWTAREA - Total Wetted Area Range: 1200 to 32,900 (FT<sup>2</sup>)

Total wetted area relates to parasite drag, which in turn is a measure of the thrust required to attain a given mach number which relates to airframe strength. TWTAREA also directly measures the size of the airframe.

4. TOGMAX - Maximum Takeoff Gross Weight Range: 24,500 to 764,000 (LB).

Airframe weight relates to the cost of material and the labor to put it in place as well as the maximum takeoff gross weight.

5. PROTO - Number of Prototype Aircraft R

Range: 2 to 42 Number in first buy

Proto is simply the number of aircraft purchased under the research and design phase of the program. It significantly influences tooling, engineering, and manufacturing labor (10:62).

### Dependent Variables:

1. ENG - Engineering Labor

Includes all direct and overtime labor charges except premium pay, including off-site labor where applicable plus the systems engineering and program management required to design and analyze the airframe and provide liason for its construction.

2. TOOL - Tooling Labor

Includes all direct and overtime labor charges except premium pay, including off-site labor where applicable, to provide tools to manufacture the airframe.

### 3. MANF - Manufacturing Hours

Includes all direct and overtime labor charges except premium pay, including off-site labor where applicable to manufacture of airframe.

## 4. MANMAT - Manufacturing Materials

Includes material to manufacture the airframes plus manufacturing and quality control, travel, relocation and premium pay; procured materials under termination; shipping charges; insurance on aircraft; applicable Government Furnished Equipment and Contractor Furnished Equipment material; and miscellaneous charges.

## 5. ODC - Other Direct Changes

Includes Special Test Equipment; tooling materials; travel, relocation and premium pay for engineering and tooling labor. (10:60)

The data consists of independent and dependent variables gathered on 16 aircraft: 4 attack, 4 cargo, and 8 fighters. A complete listing of the data can be found in Appendix A.

### Statistical Procedures

The procedures utilized during this research will be factor analysis and regression analysis. The following is a brief description of these analyses and the statistical implications.

## Factor Analysis

Factor analysis is a multivariate technique to reduce a number of variables to a few interpretable constructs. Factor analysis is used primarily for grouping data on a statistical basis and empirical clustering of observations. Simply stated, factor analysis develops a few constructs for the total set of observed variables based on interrelationships. None of the variables are treated differently from the others, as consisted to multiple

regression, in which one variable is considered the criterion (dependent) variable and all others the predictor (independent) variables. Factor analysis considers each of the observed variables as a dependent variable which is a function (construct) of some underlying, latent, and hypothetical factors. Conversely, each factor can be looked at as the dependent variable which is a function of the observed variables.

Factor analysis has some basic concepts and terminology. A factor is a linear combination of the observed variables. In other words,

$$F = a_1 x_1 + a_2 x_2 + a_3 x_3 + ... + a_n x_n$$

In this logic, the factor equates to the dependent variable (y) in multiple regression. The primary difference between factor analysis and multiple regression is that the total observed variables are grouped in a manner such that more than one factor is derived. Therefore, the following relationship may be developed using factor analysis

$$F_1 = a_{11}x_1 + a_{21}x_2 + a_{31}x_3$$
 $F_2 = a_{42}x_4 + a_{52}x_5$ 
 $F_3 = a_{63}x_6 + a_{73}x_7$ 

The above analysis develops a three factor relationship derived by using seven variables. The first factor consists of three variables  $(x_1, x_2, x_3)$ , the second  $(x_4, x_5)$  and the third  $(x_6, x_7)$ . The important point to remember is that each factor has coefficients for all seven variables in the analysis but the coefficients may be zero or close to zero. Factor analysis also provides a predicted score, similar to a regression analysis estimate (y), for each individual factor developed, which is called a factor score. Therefore,

$$F_i = a_1 x_{1i} + a_2 x_{2i} + ... + a_n x_{ni}$$

Thus, a primary difference between regression and factor analysis is that each observation will be assigned as many factor scores as there are factors and not just one score. The factor scores are summarized in a factor scores matrix for each sample (analysis). The factor score is correlated with the observed score for each variable, and summarized in a factor loadings matrix. Factor loading can be described as the correlation between the scores. If there are n variables and r factors, there will be a total of  $(n \times r)$  factor loadings.

There are three useful techniques to describe the relationship represented by a factor loadings matrix. The first is the eigenvalue, which is mathematically identical to R<sup>2</sup> used in multiple regression. To obtain the eigenvalue, square the loadings of each factor and sum to get a "sum of squares" for each factor. Each eigenvalue summarizes a fraction of total variance. In order to obtain the variance explained by a particular factor, its corresponding factor score sum of square must be divided by the number of factors developed by the analysis. As an example, if the sum of squares equal 2.68 for factor number 3, and there are six factors in the factor loadings matrix, the variance explained by factor 3 would be 2.68/6 = .447 or 44.7% of the total variance is explained by this factor. The second technique is called communality (h<sup>2</sup>), which represents the variance of each variable summarized by two factors. Simply stated communality is the percentage of total variance which is summarized in common factors. Common factors are those factors which are shared by at least two variables. All other factors are call unique factors. The third technique involves correlation prediction. Each factor loading represents a correlation between a variable and a factor. Therefore, the predicted correlation between two variables can be generated by multiplying their factor loadings on each factor and summing. As an example, if .68 and .59 are the factor loadings for the first factor, variables one and two, and .28 and .32 are the factor loadings for the second factor, variables one and two, then the correlation between variable one and two would equal  $(.68 \times .59) + (.28 \times .32) = .49$ .

Factor analysis is a multivariate statistical technique which can be described as a set of techniques. It is intended that the preceeding pages merely describe the basis of the procedures to be used in this thesis. Factor analysis is utilized to justify the development of separate cost equations for the airframes of fighters, attack and cargo. Conducting factor analysis on the performance characteristics of the airframe should result in a grouping of factors that correlate with at least two definite groups, fighter and cargo. If the above stated hypothesis can be statistically supported, then the development of a cost estimating equation for each different type of airframe during the RDT&E phase of an acquisition would appear justified. Additionally, if attack airframes do not appear statistically different from the fighter airframes, then one general equation can be developed for both types. Following the factor analysis portion of the research, the data is regressed to develop CERs for each dependent variable based on the factor loading groupings.

### Regression Analysis

The regression procedure utilized in this thesis is a linear multiple regression. This means that the relationship between y (the dependent variable) and each one of the independent variables is linear when expressed in logarithms. Assuming linearity, and letting  $B_{\Omega}$  (Beta) equal the

y-intercept,  $B_1$  equal the slope of the relationship between y and  $x_1$ ,  $B_2$  equal the slope between y and  $x_2$  and so forth, until the list of independent variables is exhausted (represented by  $B_{in} \times_m$ ), plus an error term (e), yields the resulting regression equation:

$$y = c + B_1 x_{1i} + B_2 x_{2i} + \dots + B_m x_{mi} + e_i$$

The coefficients  $B_1$ ,  $B_2$ , ...  $B_n$  are called partial regression coefficients, since they indicate the influence of each independent variable on y with the influence of all other variables held constant.

There are seven important assumptions when using multiple regression. They are:

- Assumption 1. The e, are all independent of each of the m independent variables.
- Assumption 2. The errors for all possible sets of given values  $x_1$ ,  $x_2$ ,....  $x_m$  are normally distributed.
- Assumption 3. The expected value of the error is zero for all possible sets of given values.
- Assumption 4. The variance of the errors is constant for all possible sets of given values.
- Assumption 5. Any two errors e and e are independent, therefore, the covariance is zero.
- Assumption 6. None of the independent variables is an exact linear combination of the other independent variables.
- Assumption 7. The number of observations (n) must exceed the number of independent variables (m) by at least two (i.e., n m + 2) 5:411, 412.

The procedures used in this thesis consist of log-linear step-wise regression. A statistical text book will provide a more detailed explanation of the regression procedures and statistical testing. However, the most important aspect of regression analysis testing which is pertinent to this thesis is explained. In order to understand regression and the testing for

significance the following concepts must be understood: the sum of square total (SST or total variation) is equal to the sum of square error (SSE or unexplained variation) plus the sum of square regression (SSR or explained variation). This can be written as:

$$SST = SSE + SSR$$

$$\sum_{i=1}^{n} (y_i - \bar{y})^2 = \sum_{i=1}^{n} (y_i - \hat{y}_i)^2 + \sum_{i=1}^{n} (\hat{y}_i - \bar{y})^2$$

Where:

 $\overline{y}$  = the average value for y

y; = the actual value for the i<sup>th</sup> observation

 $\hat{y}_i$  = the predicted value to the i<sup>th</sup> observation

This relationship provides the basis for testing for the significance of the regression equation. The statistical tests used in this thesis are defined below. These tests indicate the "goodness of fit" of the model and establish relative error bounds on predictions.

Mean Squared Error (MSE) is an unbiased estimator of the model's variance, and is obtained by dividing SSE by the degrees of freedom.

MSE 
$$=\sum_{i=1}^{n} (y_i - \hat{y}_i)^2 = \frac{SSE}{n-k}$$

Where:

y: = dependent variable

 $\hat{y}_i$  = regression estimate for  $y_i$ 

n = number of observations

k = number of independent variables

k+1 = number of parameters estimated

SSE = sum of squares error.

A small mean squared error is desired and is indicative of a good estimate for y and a small degree of error. This can also be stated as such: a small MSE indicates that a significant portion of the variance between  $y_i$  and  $y_i$  is explained by the regression equation.

The Coefficient of Determination  $(R^2)$  measures how well the explanatory variables account for the variations in the actual cost data. The coefficient  $R^2$  measures the proportion of total variance about the mean of y that is explained by the regression.

$$R^{2} = 1 - \frac{\sum_{i=1}^{n} (y_{i} - \hat{y}_{i})^{2}}{\sum_{i=1}^{n} (y_{i} - \hat{y})^{2}} = 1 - \frac{SSE}{SST} = \frac{SSR}{SST}$$

Where:

y<sub>i</sub> = dependent variable

 $\hat{y}_i$  = regression estimate of  $y_i$ 

 $\overline{y}$  = mean of dependent variable

SSR = sum of squares regression.

SST = sum of squares total

Ideally, the coefficient of determination can be written as:

The value of  $R^2$  lies between zero and one and can be directly converted to the coefficient of correlation by taking the square-root of the value. This thesis uses  $R^2$  since its interpretation can be better utilized than can the coefficient of correlation.

Another useful statistic is Students' t, which is used to determine the significance of an individual parameter, and is used in computing the confidence intervals and prediction intervals.

To test the significance of an individual coefficient  $(B_i)$  in the regression equation, a test is used which is similar to that for the slope in simple linear regression. The null hypothesis,  $H_o: B_i = \emptyset$ , means that the variable  $x_i$  has no linear relationship with y, holding the effect of the other independent variables constant. The best linear unbiased estimate of  $B_i$  is the sample partial regression coefficient  $b_i$ . Under the assumption that the error is normally distributed, the test for the null hypothesis follows the t-distribution with n - (k + 1) degrees of freedom

$$H_0: B_i = 0$$

Then:

$$t = \frac{b_i - 0}{S_{bi}}$$

Where:

H<sub>2</sub> = Null hypothesis

B<sub>i</sub> = Coefficient of the regression equation

b; = Sample partial regression coefficient

S<sub>bi</sub> = The amount of sampling error in the regression coefficient b; which can be written as:

$$S_{bi} = \frac{SSE}{n-(k+1)} \cdot \frac{1}{\sum_{i=1}^{n} (x_i - \overline{x})^2}$$

#### Where:

SSE = sum of squares error

n = number of observations

k+l = number of parameters estimated

k = number of independent variables

x; = independent variable

 $\bar{x}$  = mean of independent variables

When the generated value for t exceeds the critical value of t (determined from a t-distribution table), then the null hypothesis of no significance is rejected.

To construct a confidence interval for B<sub>i</sub>, the equation below is used.

$$b_i - t (a/2, n-2) S_{bi} \le B \le b_i + t (a/2, n-2) S_{bi}$$

### Where:

a = level of significance

a/2 = one half of the significance level (two-tailed
test)

The t statistic is used to construct a confidence interval around the regression coefficients for comparison with the regression coefficients of the base model, and then to test for signficance using the base model as the null  $(H_0)$  hypothesis. This test can only be utilized for those portions of the regression equation that are similiar. If the regression equations differ not only in terms of B coefficients but also in terms of independent variables the F-test is used to compare the two models. In fact, model x will not be directly compared to model y but will be compared to the same basic hypothesis  $(H_0)$ . This type of comparision will result in the comparison of the model by standarized statistical measures such as  $R^2$  and the F-ratio.

The F-test is based upon the common null hypothesis that there is not a linear relationship at all in the population, i.e., that all B values are equal to zero.

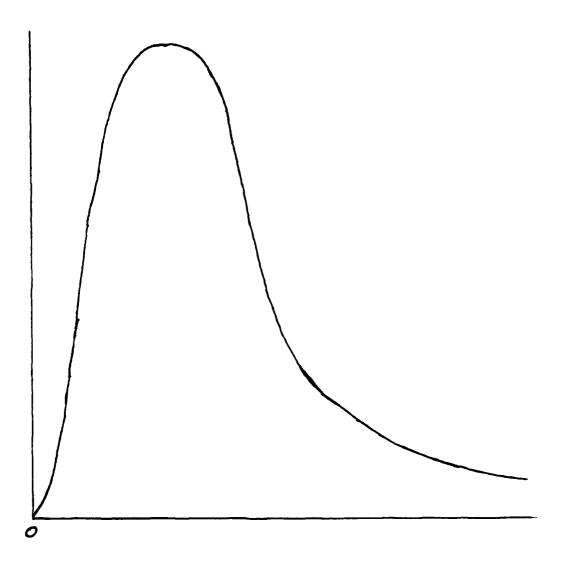
$$H_0: B_1 = B_2 = \dots = B_m = \emptyset$$

If this hypothesis were true SSE would be large and SSR would be small. In order to obtain the F-ratio, the values for SSE and SSR are divided by their relative degree of freedom (d.f.). The resulting ratios are called the mean-square regression (MSR) and the mean-square error (MSE); the ratio of MSR to MSE follows the F-distribution and is the  $F_{(CALC)}$  value.

The degrees of freedom associated with SSE is n-(k+1), because (k+1) parameters are being estimated. The degree of freedom for SSR is the number of independent variables. Therefore the appropriate statistical measurement to test the null hypothesis is the ratio of MSR to MSE, which follows the F-distribution with appropriate degrees of freedom (Figure 1). Therefore, the  $H_0 = B_1 = B_2 = \dots = B_m = \emptyset$  is tested by:

$$F_{CALC} = \frac{SSR/k}{SSE/(n-k+1)} = \frac{MSR}{MSE}$$

To determine the significance of an individual coefficient (B<sub>i</sub>), the t-test should be applied (assuming the error is normally distributed). This statistic is part of the computer output and verifies the significance of the coefficient. Additionally, the F-test is used to test the null hypothesis (no linear relationship) at the levels of significance of 0.05 and 0.01. These results of the thesis generated model are then compared to the base model in an attempt to determine the relative accuracy and confidence in the regression equations.



The F-Distribution

Figure 1

## Summary

This section provides the basic statistical background required to comprehend the analytical results presented in the following chapter. Chapter IV presents analysis of the data. The data analysis starts with a review of the data to determine whether the independent variables are logical estimators (cost drivers) of the dependent variables. Upon completion of the data review, the results and findings of the factor analysis are presented. The results are then used as inputs for the subsequent regression analysis. Once the regression results are examined, the equations are compared to the base model in order to determine which model more accurately estimates airframe RDT&E costs.

#### **CHAPTER IV**

#### **ANALYSIS**

The analysis in this chapter is presented in five distinct phases. First, the expected logical parametric relationships are developed for each dependent variable. Second, the airframe type groupings are developed based upon the results of the factor analysis. Third, the resulting airframe type groupings are regressed using both the dependent and independent variables for each group. Fourth, the expected logical parametric relationships are compared to the regression equations. Finally, the results of this regression are compared to the base model (Grumman MLCCM, 1980).

## Parametric Relationships

Logical relationships between the dependent and independent variables must be developed to provide a basis for comparision to the subsequently developed regression equations before any analysis is accomplished. Development of these relationships serves several purposes. First, the development process serves as a crosscheck of the independent variables relationship with the dependent variables. Statistically, it is possible to have a good apparent predictor (independent variable) that is totally unrelated to what it accurately predicts (dependent variables). Therefore, the development of the logical relationship serves as a filtering process, eliminating those variables that are unrelated and retaining those variables that are logically related to the variable being estimated. Secondly, the relationships can be used as a basis of support for the subsequent regression

equations. And finally, the development process serves as an instrument to support the validity of the analysis.

The major assumption contained in our parametric relationship analysis is that the variables defined by the base model are in fact cost drivers of the dependent variables. Based upon this assumption, the hypothesized order of entrance and relative importance of the independent variables are discussed in the following paragraphs, with the anticipated parametric relationship logically developed for each cost element.

The logical relationships presented below are for each of the dependent variables with each independent variable. It should be noted that the independent variables are listed in the order of expected influence on the dependent variable. In the development of relationships, the first one or two independent variables which enter the equation are expected to explain the major portion of the dependent/independent variable relationship. The order of entrance of the remaining three or four variables is exceedingly difficult to estimate without performing a statistical measure of correlation with the initial independent variables and the dependent variable (See Chapter III). In general, we expect the value of the dependent variables (measures of estimated airframe costs) to increase as the size, performance or number of prototype increase.

#### The variables are:

## Independent

### Dependent

NZULT - Ultimate Load Factor

ENG - Engineering Hours

MAXMACH - Maximum Mach

ODC - Other Direct Charges

TWTAREA - Total Wetted Area

MANMAT - Manufacturing Materials

TOGWMAX - Total Takeoff Weight

**TOOL - Tooling Hours** 

PROTO - Number of Prototypes

MANF - Manufacturing Hours

Before proceeding with the parametric relationships it is important to review the definitions of both the independent and dependent variables presented in Chapter 3.

## **Engineering**

Engineering relates to the direct and overtime labor hours required to design and analyze the airframe and provide liaison for its construction. In estimating this cost element it is logical to assume that three groups of independent variables would dominate the estimated regression equations. The three groups are represented by size (TOGWMAX and TWTAREA), complexity (MAXMACH and NZULT), and the number of prototypes (PROTO). One variable from each of these groups would logically enter the estimated regression equation before the second variable from either size or complexity would enter the equation. This stated relationship forms a basic rule for estimating the regression equations. However, this rule may be overridden when a particular dependent variable appears heavily skewed towards one of the groups. Based on this logic, the following represents the hypothesized regression equation for engineering hours.

ENG = Function (TOGWMAX, PROTO, NZULT, TWTAREA, MAXMACH).

There is a possibility that the grouped variables representing size and complexity are likely to exchange positions depending upon the correlation with the dependent variable. However, in estimating the regression equation for Engineering the rule pertaining to the groups appears to apply. Therefore, the order of entrance of the first three independent variables is likely to be one variable from each of the three groups since the engineering dependent variable, by definition, is correlated to size, complexity, and the number of prototypes.

### **Tooling**

Tooling includes all direct and overtime labor charges, except premium pay, including off-site labor, to provide tools to manufacture the airframe. The tooling equation is likely to enter only one independent variable representing each of three dominant groups, before entering the second variable from any of the dominant groups defined above. Logically, tooling is significantly correlated to the complexity and size of the airframe. This logic dictates that a factor representing size and complexity must be assigned the first and second positions in the estimated step-wise regression equation. The following is a prediction of the expected step-wise regression.

TOOL = Function (NZULT, TOGWMAX, PROTO, MAXMACH, TWTAREA).

There is a possibility that the grouped variables representing size and complexity are likely to exchange positions depending upon the correlation with the dependent variable.

## Manufacturing and Quality Control

Manufacturing and Quality Control (QC) include all direct and over-time labor charges except premium pay, including off-site labor to manufacture the airframe. By definition, manufacturing and QC are directly related to the size and complexity of the airframe. In this case, the significance of PROTO would only be great if the number of prototypes is large. Therefore, it is expected that both variables from the groups representing complexity and size would enter the step-wise regression equation before PROTO.

The step-wise regression equation is expected to resemble the following hypothesized equation.

MANF = Function (NZULT, TOGWMAX, MAXMACH, TWTAREA, PROTO).

Again there is a possibility that the grouped variables can exchange locations within the estimated equation depending upon correlation with the dependent variable. Additionally, there is a possibility that the group representing size could enter both independent variables, before the group representing complexity, based upon correlation with manufacturing hours.

# Manufacturing Materials

Manufacturing Materials includes the material used to manufacture the airframe plus other miscellaneous charges such as: QC, travel, relocation and premium pay, shipping charges, insurance, Government Furnished Equipment (GFE), and Contractor Furnished Equipment (CFE). Manufacturing materials is skewed towards the actual materials required to assemble the airframe. Therefore, it is logical to expect that the dominant

groups are the number of prototypes and size. It is highly possible that both size variables can enter the step-wise regression equation before either variable representing complexity. The following is the hypothesized step-wise regression equation for manufacturing materials.

MANMAT = Function (PROTO, TOGWMAX, TWTAREA, NZULT, MAXMACH).

Furthermore, there is a possibility that the members of the groups may exchange places with each other in the hypothesized step-wise regression equation, or that one of the complexity variables can preced one of the size variables. However, it is highly unlikely that any variable can displace the prototype variable.

## Other Direct Charges

Other direct charges (ODC) include Special Test Equipment (STE), tooling materials, relocation and premium pay for engineering and tooling labor. Other direct charges are significantly related to the number of prototypes due to STE and other miscellaneous areas that arise during prototype construction. Additionally, ODC is related to engineering and tooling, so logically ODC is dependent upon the most significant estimator from engineering and tooling. The following is a hypothesized step-wise regression equation for ODC.

ODC = Function (PROTO, NZULT, TOGWMAX, MAXMACH, TWTAREA).

Once again, there is a possibility that fluctuations may occur between either the size and complexity groups, or between the variables within a group. However, it is unlikely that either group would place a variable ahead of the prototype variable in the ODC equation.

## Factor Analysis

The purpose of factor analysis is to reduce a number of variables to a few interpretable constructs. The process described below is presented to provide an understanding of how the groupings are developed for the step-wise regession analysis.

The following analytical procedures are used: First the data are prepared. The data used are the structural characteristics of the airframe:

1) TOGWMAX, 2) TWTAREA, 3) NZULT, and 4) MAXMACH. Data are used for six different airframes within each airframe type.

<u>Fighter</u>	Attack	Cargo
F-4	A-3	C-2
F-6	A-4	C-130
F-14	A-5	C-133
F-15	A-6	C-135
F-16	A-7	C-141
F-102	A-10	C-5

Second, factor analysis is then performed on the data set, resulting in constraints that are used to develop logical groupings by airframe type for the step-wise regression. Third, the results are analyzed to determine whether the whole data set (Fighter, Attack, and Cargo) or a subset of the data set (Fighter alone, Attack alone, Cargo alone, or some combination) is to be used for the step-wise regression.

The initial factor analysis is run using the four structural design variables for each airframe. The factor run results in four factors being developed. Initial review of these factors shows that the first three factors support a communality among the data. However, the fourth factor exhibits a grouping of Fighter and Attack. This grouping is based upon the positive factor loadings for TWTAREA, NZULT, and TOGWMAX, while the cargo factor loadings tend to be negative (See Table 1).

218#=				
2198=	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4
2286=				
2218= FTWT	.161 <b>86</b>	.94929	.11259	.18324
2228= FNZU	.94518	36935	.84962	.84711
2236= FMXM	.52783	17676	.76819	.25196
2248= FTOG	.233 <b>6</b> 8	.276 <b>6</b> 8	.81393	.39679
2258= ATWT	.93478	.24228	11 <b>6</b> 73	.17696
2268= ANZU	.82586	17645	.37197	.9:265
2278= ANXH	.16827	.28212	94998	.16729
228#= ATOG	.8 <b>8</b> 927	.4826#	65668	.34939
229#= CTWT	.86712	85426	.3621 <b>8</b>	39787
23 <b>98</b> = CNZU	.82968	.88575	16731	32512
2316= CMXM	.53389	71369	.37328	.82475
232 <b>5</b> = CTOC	17313	64591	.#8667	97999
733 <b>6</b> =				

Table I
Initial Factor Loadings

Further analysis of the factor run centers on the eigenvalue, communality  $(h^2)$ , and the correlation between a variable and a factor (these techniques are presented in Chapter 3). Using the above table, the correlation between variables and factors are obtained. As an example, Fighter TWTAREA (FTWT) = .161 for Factor 1 and .94929 for Factor 2;

likewise, Fighter NZULT (FNZU) = .94518 for Factor 1 and - .3095 for Factor 2 and so on across the matrix. To obtain the correlation the formula would be:

(FTWT Factor 1 X FNZU Factor 1) + (FTWT Factor 2 X FNZU Factor 2) + (FTWT Factors X FNZU Factor 3) + (FTWT Factor 4 X FNZU Factor 4)

#### Therefore:

$$(.161 \times .945) + (.949 \times .309) + (.113 \times .049) + (.183 \times .049) + (.183 \times .047) = -.127$$

Subsequent correlation generation is possible, but the overall result is presented in Table 2. The table is read across rows; the first line is read that Factor 1 is correlated to itself with a value of .80559. Factor 1 is correlated to Factor 2 negatively (-.08452), to Factor three positively (.46793), and to Factor 4 positively (.35345).

2419= 2429= 2439=		FACTOR	1	FACTOR	2	FACTOR	3	FACTOR	4
2446= FACTOR 2456= FACTOR	1 2	.8 <b>#</b> 55		<b>6</b> 845	_	.4679 3961	-	.3534 . <b>6</b> 596	-
2468= FACTOR	3	4664	1	1945	2	2849	4	8382 4189	:3
2478= FACTOR 2488=1FACTOR 2498=		2156 S	,	.4499	,	.7629 <b>6</b> 3/	-	2 14.42	-

Table 2
Factor Score of the Initial Factor Analysis

The eigenvalues are presented in Table III. The table is read across the rows; therefore, FTWT on Factor 1 has an eigenvalue equal to 4.52772. This eigenvalue is then divided by the number of factors presented in the table, which is equal to 12 factors. This procedure indicates the percentage of total variance explained by FTWT through Factor 1. By reading down the cumulative percentage (CUM PCT) column it is apparent that only four factors are required to explain 100% of the data's variance. This table reinforces the fact that only four factors are presented in the Factor Matrix presented in Table 3.

15:3=						
152#=	VARIABLE	EST COMMUNALITY	FACTOR	EIGENVALUE	PCT	CUM PCT
1536=				22	٠, ٠,	CON 1 CT
1548=	FTUT	1.58866	1	4.52772	37.7	37.7
155∉=	FNZU	1.00000	2	3.63168	25.3	63.6
1569=	FHXH	1.66565	3	2.25841	18.8	81.8
157#=		1.36543	4	1.86523	15.5	96.9
158 <b>6</b> =		1.06666	5	.37784	3.1	194.5
1594=		1.58888	ь	. 20022		199.8
1696=		1.68886	7	. 56062	.\$	1 <b>99.5</b>
1618=		1.8666	8	. 66866	. \$	196.8
1629=		1.6666	9	.68688	.#	166.6
163#=		1.99999	18	89956	5	166.6
1649=		1.55656	11	68888	\$	100.0
165#=		1.06666	12	86666	#	198.6
	FACTOR AN	alysis		<b>5</b> 3/	22/82	14.42.32.
147 <b>6</b> ±						

Table 3
Factor Matrix for the Initial Factor Analysis

Communality is defined as the variance of each variable summarized by two factors, or simply, the percentage of total variation explained by common factors. The values for communality are presented in Table 4. The table is read across the rows; as an example, the communality value for FTWT is equal to .97332. This value expresses the fact that 97.332% of FTWT variance is explained by other factors utilized in the factor analysis run, or that FTWT only contributes 2.6% towards the 100% explained by the combination of all variables. The communality table shows all variables to have a communality of .90 or greater, which means that no single variable is the primary determinant of a Factor (Quartimax Rotation).

193#= 194#= VARIABLE	COMMUNALITY
195#=	CONNONNETEL
1969= FTNT	.97332
1976= FNZU	.99374
1986= FMXM	.96299
199#= FT0C	.95847
2888= ATWT	.976#5
2010 = ANZU	.99997
2 <b>6</b> 26= Amxm	.99962
2030= ATOC	.986#5
2949= CTWT	.9438#
2 <b>858</b> = CNZU	.98265
2368= CHXM	.93434
2070= CTOG	.99998
2889=1FACTOR ANALY	'SIS
2090=	

Table 4
Communality of the Initial Factor Analysis

Further investigations are required to ascertain whether there really exists a definite grouping of the fighter and attack airframe types. To resolve this issue, several artificial variables were created for each airframe type. The first is TWTAREA divided by TOGWMAX, and is used to represent a characteristic of the airframe size.

FF = Fighter TWTAREA + Fighter TOGWMAX

AA = Attack TWTAREA + Attack TOGWMAX

CC = Cargo TWTAREA + Cargo TOGWMAX

The second is NZULT multiplied by MAXMACH, and is used to represent the performance and handling characteristics of the airframe.

FN = Fighter NZULT X Fighter MAXMACH

AN = Attack NZULT X Attack MAXMACH

CN = Cargo NZULT X Cargo MAXMACH

And finally, NZULT is divided by MAXMACH, and is used to represent a ratio of g-load environment to maximum mach.

FM = Fighter NZULT + Fighter MAXMACH

AM = Attack NZULT + Attack MAXMACH

CM = Cargo NZULT + Cargo MAXMACH

Three more factor analyses are run using these artificial variables. The initial factor analysis run using FM, AM and CM results in only one factor being developed. However, this one factor tends to show more support for a fighter/cargo grouping, with both the values for CM and FM positive (Table 5).

1260=	
1276=	FACTOR 1
1280=	, HOTOR 1
129 <b>6</b> = FM	.42362
13 <b>66= N</b> H	
,	39671
131 <b>5</b> = CM	.361 <b>6</b> 7
1324=	

Table 5
Factor Score of the Environment

In this particular case no correlations are developed because only one Factor exists. However, the eigenvalues for this run are presented in Table 6. Once again, the cumulative percentage is equal to 100, which indicates that the variables are explaining the total variance among themselves.

55#=		•		
566= VARIABLE	KEAN	STANDARD BEV	CASES	
57#=				
58#= F#	6.5272	2.7336	6	
598= NH	8.6154	7.1615	6	
6ØØ= CM	5.7018	1.8517	6	
619=1FACTOR ANALYSIS			63/22/82	15.34.38.
62 <b>9</b> =				

Table 6
Factor Matrix of the Environment

The communality of these three artificial variables are presented in Table 7. The table indicates that although 100% of variation is explained,

there is a possibility that significant differences exist for these three variables. The differences are recognized by the fact that the communality loadings are not extremely high (close to one), but are in the .60 to .80 range. Therefore, unexplained variance within the variables exists, and is possibly explained by other variables or artificial variables (Quartimax Rotation).

1868=		
1878=	VARIABLE	COMMUNALITY
:000=		
139#=	FĦ	.82159
1109=	NM	.72255
1116=	CM	.59858
1128=		

Table 7

Cummunality of the Environment

The second factor analysis using FN, AN, and CN as the artificial variables results in two factors being developed. Once again, factor one tends to show a relationship for a fighter/cargo grouping. However, factor two shows the opposite relationship, supporting a fighter/attack grouping (Table 8).

154 <b>9=</b> 155 <b>%=</b>	FACTOR 1	FACTOR 2
1568=	racion 1	rncion 2
1570= FN	.44647	.33338
158 <b>8</b> = An	15728	.81882
:596= CN	.78941	27894
:599=		

Table 8
Factor Score of Performance

Correlation for the variables are developed from the above table and result in a positive correlation between fighter and attack (.00413), a negative correlation between cargo and attack (-.00124) and a negative correlation between fighter and cargo (-.05). The correlations indicate that there is little justification in grouping one airframe type with another.

The eigenvalues for this factor run are provided in Table 9. Again the cumulative percentage is equal to 100, with CN contributing the final 10.2 %. In analyzing, the communalities for FN, AN, and CN it is apparent that there is a relatively high communality between these three artificial variables. Which means 80% to 93% of the variance is explained by the two factors.

86#=						
67⊈=	VARIABLE	EST COMMUNALITY	FACTOR	EIGENVALUE	PCT	CUM POT
88 <b>8</b> =						
89#=	FN	1.98988	1	1.65541	55.2	55.2
984=	AN	1.66686	2	1.03741	34.6	89.6
918=	CN	1.00000	3	.32718	18.2	189.6
922=	FACTOR AL	valysis		<b>9</b> 3.	122/82	15.18.55.
934=						

Table 9
Factor Matrix of Performance

The third factor analysis is run using FF, AA, and CC as the artificial variables and results in two factors being generated. Factor one shows a diverse range: AA highly positive, CC highly negative and FF approximately equal to zero (Table 10). Therefore, factor one tends to show support for three different groups, one for each one of the airframe types. Factor two shows support for grouping attack and cargo airframes, with a high positive factor loading for the fighters and extremely close negative factor loadings for the attack and cargo airframes.

1529=		
153#=	FACTOR 1	FACTOR 2
154#=		THE TON 2
155#= FF	81679	.96485
1568= AA	.58936	16798
1578= CC	56878	13599
1584=	100070	

Table 10

### Factor Score of Size

Correlations for the variables are developed from the above table and result in positive correlation between fighter and attack (.00015), a negative correlation between cargo and attack (-.008), and a negative correlation between fighter and cargo (-.013). Again, the correlations indicate little support for grouping the airframe types.

The eigenvalues and communalities for the FF, AA, and CC are presented in Table 11. In reading both tables, it is apparent that the two factors that are developed explain a relatively high percentage of the variation of the artificial variables, but again indicate that a portion of the variation in each is not explained by either factor.

84#=						
85#= V	ARIABLE ES	T COMMUNALITY	FACTOR	EIGENVALUE	PCT	CU: PCT
€£8=						
87 <b>9</b> = =	F	1.98869	1	1.56632	56.6	54.4
884= A	A	1.66566	2	1.81887	33.9	83.9
896= C	_	1.06863	3	.48161	16.1	166.6
966=1F	ACTOR ANAL	YSIS		<b>6</b> 3,	22/82	15.26.29.
Q142						

Table 11

Factor Matrix of Size

### Factor Analysis Summary

Factor analysis supports grouping by airframe type, and thus, a separate CER for each airframe type must be developed. This conclusion is drawn on the basis of the four previously analyzed factor analysis runs. Each of the four runs indicate that there are fluctuations and variations internal to the airframe types. This is apparent in the factor loadings, where in one case the loadings would indicate a grouping and in another case it would support the opposite grouping. However, the most important of the decision criteria remains very consistent, that is the correlation between a variable and a factor. In every case identified there exists a correlation between the airframe types that is extremely close to zero. This overriding criteria indicates that a separate CER for each airframe type should be developed.

#### Regression Analysis

The regression procedures utilized in this chapter are identified in Chapter III, except for one point of clarification. The regression process is a multiple step-wise regression in lieu of merely a multiple regression. The difference is extremely important for the process of analyzing the regression analysis results. Pure multiple regression generates the same results (given the same data) as a step-wise regression. However, a step-wise regression generates a table, identifying the order in which the variables entered the regression equation. This is important in that the effects of each independent variable can be analyzed as it enters the regression equation.

The initial step-wise regression is accomplished using the same data base as the base model; however, the second step-wise regression utilizes

two artificial variables, TT and MXNZ. The artificial variable TT is obtained by multiplying TOGWMAX by TWTAREA, and is used to represent the overall size and weight of an airframe (square foot pounds). The artificial variable MXNZ is obtained by mutliplying MAXMACH by NZULT, and is used to represent the total flying environment created when flying a high-g airframe at a high mach (synergistic effect of speed and load factor).

# Initial Regression

The initial regression is accomplished using the data base identified in Appendix A. The data base consists of all 16 aircraft (8 fighters, 4 attack, and 4 cargo) and is utilized for comparison with the base model. The initial regression results in five equations being developed, one for each dependent variable (Engineering, Other direct charges (ODC), Manufacturing Materials, Manufacturing Labor, and Tooling). The following is the result of the initial regression analysis.

The initial dependent variable that is regressed is ODC, and results in the following regression equation being developed.

Ln(ODC) = -10.3184 + (.5661 Ln(PROTO)) + (.8483 Ln(TOGWMAX)) + (1.1559 Ln(NZULT)) + (.212 Ln(TWTAREA)) + (.3503 Ln(MAXMACH))

The regression equation results in an  $R^2$  value equal to .889, which means that the equation explains 88.9% of the variance of the ODC dependent variable. The calculated F = 16.025, with 5 and 10 degrees of freedom, and is significant to the .991 level of confidence. Additionally, the beta values computed from the regression form the following confidence intervals at the 95% confidence level (Table 12).

2286=			
229#= COEFFICIE	NTS AND CONFI	DENCE INTER	VALS.
2384=			
2310= VARIABLE	8	95 PCT	C.I.
232 <b>9</b> =			
233#= PROTO	.5661	.2545	.8776
2348= TOGWHAX	.8483	.2974	1.3992
2350= NZULT	1.1559	0872	2.3198
2368= THTAREA	.2126	1201	.5441
2378= MAXMACH	.35ø3	288€	.9886
238#= CONSTANT	-18.3184	-17.4998	-3.1371
239#=			

Table 12
Initial Regression Equation Summary (ODC)

The estimated values generated by the regression analysis result in a regression line that predicts the actual values with a relatively high accuracy. None of the predicted values differ from the actual values by more than two standard deviations (Figure 2). In review of the residuals presented in Figure 2, the majority of the estimated values are close to the actual values with the exception of three outlying estimates (.4585 equals one standard deviation).

```
2746=
2750= + + + + + + + + + HULTIPLE REGRESSION + + + + + + + +
2768=
2778=
2788= RESIDUAL PLOT.
2798=
                  Y EST. RESIDUAL -2SD
                                                       3.0
                                                                         +255
       Y VALUE
1888=
2818=
                              -.145
          2.605
                    2.95#
2828=
                               .221
                                                        I
                    2.254
2330=
          2.476
                    4.418
                              -.834
                                                        I
          3.575
2848=
                               .428
                                                        ı.
                    4,585
235#=
          4.613
                    5.775
                               .434
                                                        I
          4.258
2868=
2878=
          3.466
                    3.387
                               .161
                                                        Ī
                    4.577
                               .:34
                                                        İ
2886=
          4,71:
289#=
          4.281
                    4.857
                              -.577
                               .135
2956=
          4.847
                    4.711
291#=
          2.931
                    2.8#8
                               .123
                                                        ī
                               .159
                                                        I
2925=
          5.371
                    5.211
                              -.717
2938=
          4.551
                    5.267
                               .178
                    5.131
2940=
          5.301
                               .266
                                                        I
                    4.965
295#=
          5.165
                    5.683
                                .229
2968=
          5.312
                    5.623
                                .278
2970=
          5.981
298#=
2996= NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
              R INDICATES POINT OUT OF RANGE OF PLOT
3868=
 3616=
 3828=
 3836= NUMBER OF CASES PLOTTED
                                                  & PERCENT OF THE TOTAL
 3848= NUMBER OF 2 S.D. GUTLIERS
                                       # OR
 345#=
                                             DURBIN-WATSON TEST
                            2.43726
 3868= VON NEUMANN RATIO
 3978=
                                        12.
 3686= NUMBER OF POSITIVE RESIDUALS
 3698= NUMBER OF NECATIVE RESIDUALS
                                         4.
                                         8.
 3106= NUMBER OF RUNS OF SIGNS
 3116=
```

Figure 2

Residuals of the Initial Regression (ODC)

The second dependent variable to be regressed is manufacturing materials, and results in the following equation being developed.

Ln(MANMAT) = -8.1001 + (.1236 Ln(PROTO)) + (.8973 Ln(TOGWMAX)) + (1.172 Ln(NZULT)) + (.3120 Ln(MAXMACH)) + (-.0625 Ln(TWTAREA)) The regression equation results in an  $R^2$  = .9164, or 91.64% of the variance of the manufacturing material dependent variable is explained by the five independent variables. The calculated F value is equal to 21.924 with 5 and 10 degrees of freedom and is significant at the .999 level of confidence. The computed beta values form the following confidence intervals at the 95% confidence level (Table XIII).

4250=			
426#= COEFFICIEN	TS AND CONFI	DENCE INTER	VALS.
4276=			
4280= VARIABLE	£	95 PCT	C.I.
429#=			
43 <b>56</b> = PROTO	.1236	8456	.2927
4316= TOCHMAX	.8973	.5983	1.1964
4328= NZULT	1.1172	.4858	1.7485
4338= MAXMACH	.3129	9344	. 4585
434#= THTAREA	0625	2427	.1178
435#= CONSTANT	-8.1661	-11.9982	-4.2819
436#=			

Table 13
Initial Regression Equation Summary (MANMAT)

The estimated values generated by the regression analysis result in a regression line that minimizes the sum of the squared errors in the regression (Figure 3). In review of the residuals the regression equation is able to predict the actual values with varying degrees of success (.2489 equals one standard deviation).

It is important to analyze the negative beta coefficient associated with TWTAREA in the MANMAT equation. The negative beta value is in contradiction to what is expected, that is, that as an independent data parameter increases so does the cost associated with that independent parameter. This situation might result from several factors: 1) it could be

contained in the data set (existence of multicollinearity), 2) it could result from the bias contained in the regression analysis as a result of using logarithm and 3) the possibility that this independent variable's definition is incorrect (a zero line scatter indicated that this was not the case because the scattergram of the independent variable with the residuals appear to be random). It shou'd also be noted that some of the other regression equations in this Chapter also contain negative beta coefficients. This problem is addressed in Chapter V under recommendations for future research.

	•					
4768=						
4778=	Y VALUE	Y EST.	RESIDUAL	-2SD	9.8	+2\$B
478#=						
4796=	3.438	3.699	.339		1	
4888=	2.766	2.955	169		. i	• •
48:8=	3.968	4.055	-,147		`. i	
482#=	3.873	3.682	.192		i,	
4836=	5.658	5.638	.#ii		i,	
4848=	3.288	3.272	.817		i.	
485#=			899		i .	
456#=	3.916		-,4#3	•	Ī	
4876=	4.251	4.321	878	•	, ;	
£88#=	3.868	3.633	\$25		ì. i	
489 <b>8</b> =	4.88:	4.552	.249			_
4988=	4.662	4.532	.131		1	•
4918:	4.268	4.461	193		•	
4928±	3.857		.672		· i	
493#=	3.731	4.619	-,289		i `	
4946=	5.246	5.060	.187	•	i.	
495#=			•••		• •	
496#=	NOTE - (+)	INDICATES	ESTIMATE	CALCULATED	WITH MEANS SUBSTIT	ITER
4976=	R	INBICATES	POINT OUT	OF RANCE OF	F PLOT	
498#=						
1991=						
5666=	NUMBER OF	CASES PLOT	ED	16.		
5010=	NUMBER OF	2 S.D. 0071	IERS	# GR	# PERCENT OF THE	TOTAL
5829=				• • • • • • • • • • • • • • • • • • • •	- ( Billo Bill ) ( ) ( ) ( )	TO THE
5036=	VON NEUMAN	IN RATIO	2.46519	DUI	RBIN-WATSON TEST	2.25487
5646=				•••		2120401
5050=	NUMBER OF	POSITIVE RE	SIDUALS	9.		
		NECATIVE RE		7.		•
		RUNS OF SIG		9.		

Figure 3

Residuals of the Initial Regression (MANMAT)

The third dependent variable that is regressed is manufacturing labor, and results in the following regression equation being developed.

The regression equation results in an  $R^2$  = .8949, or 89.49% of the variance of the manufacturing labor dependent variable is explained by the independent variables. Additionally, the regression equation's F-value is equal to 17.038 which is significant at the .999 level of confidence. The computed beta values form the following confidence intervals at the 95% confidence level (Table 14).

6226=			
6230= CGEFFICIENT	TS AND CONFI	DENCE INTER	VALS.
6248=			
6256= VARIABLE	B	95 PCT	C.I.
626 <b>#</b> =			
6270= TOCHHAX	.8698	.5486	1.1731
6283= NZULT	.9138	.2545	1.573#
6298= MAXMACH	.3261	#357	.6878
6388= TUTAREA	1841	2923	. 8841
63:#= PROTO	.6761	1984	.2527
632#= CONSTANT	-7.1673	-11.2376	-3.8978
633 <b>6</b> =			

Table 14
Initial Regression Equation Summary (MANF)

The estimated values generated by the regression analysis result in a regression line that predicts the actual values with relatively high accuracy. However, there are some outlying predictions that are two standard deviations away from the regression equation, but one standard deviation is equal to only .2599 (Figure 4).

```
669#= + * * * * * * * * KULTIPLE REGRESSION * * * * * * * *
6798=
6718=
6728= RESIDUAL PLOT.
673#=
6744=
        Y VALUE
                   Y EST. RESIDUAL -2SD
                                                                          +2SD
675#=
676#=
          3.239
                    2.968
                               .271
6778=
          2.526
                    2.757
                              -.231
6786=
          3.864
                    3.763
                               .182
                                                        i.
6796=
                    3.215
                               .031
          3.246
                                .632
                                                        I.
6866=
                    4.695
          4.727
                               .#38
                    3.585
681#=
          3.118
                                                        Ι.
6826=
          4.578
                    4.668
                               .618
                                                        ī.
          3.738
                    4.438
                              -.386
683Ø=
                                                        1
                               .147
6846=
          4.891
                    3.944
                                                        I
685#=
          2.883
                    2.798
                                .806
                                                         I.
6866=
          4,412
                    4.172
                                .239
6878=
          4.297
                    4.136
                               .162
688#=
          3.668
                    4.869
                               -.464
689#=
          3.526
                    3.354
                               .176
6988=
          3.336
                    3.639
                               -.383
6919=
          4.745
                    4.665
                                .066
6928=
6930= NOTE - (+) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
694#=
              R INDICATES POINT OUT OF RANGE OF PLOT
695#=
696#=
6976= NUMBER OF CASES PLOTTED
                                      16.
698# NUMBER OF 2 S.D. GUTLIERS
                                       e or
                                                  # PERCENT OF THE TOTAL
699#=
7666= VON NEUMANN RATIO
                                             DURBIN-WATSON TEST
                                                                   2.82182
7016=
7828= NUMBER OF POSITIVE RESIDUALS
                                       12.
7838= NUMBER OF NEGATIVE RESIDUALS
                                        4.
7646= NUMBER OF RUNS OF SIGNS
                                        9.
7656=
```

Figure 4

Residuals of the Initial Regression (MANF)

The fourth dependent variable to be regressed is tooling hours, and results in the following regression equation being developed.

The regression equation results in an  $R^2$  = .5064, or 50.64% of the variance of the tooling dependent variable is explained by the independent variable. The calculated F-value is equal to 2.052 and is significant at the .884 level of confidence. The beta values form a wide confidence interval at the 95% confidence level (Table 15).

819#=			
8260= COEFFICIENT	S AND CONFI	DENCE INTER	ALS.
821 <b>9</b> =			
8220= VARIABLE	8	95 PCT	C.I.
823 <b>6</b> =			
824#= NZULT	-4.8523	-7.4573	6473
825#= MAIMACH	1.7124	1561	3.58#9
8266= TOCHMAX	8878	-2.5885	.7249
827#= PROTO	.2988	6133	1.2168
8288= THTAREA	.2972	6749	1.2694
829#= CONSTANT	16.7166	-4.3863	37.7395
83##=		,	

Table 15
Initial Regression Equation Summary (TOOL)

The estimated values generated by the regression analysis result in a regression line that minimizes the sum of the squared errors in the regression (Figure 5). The residual plot depicts the actuals in comparison with the estimated and must be interpreted correctly. Even though the actuals are within 1 to 1.5 standard deviations the actual standard deviation is larger for this regression analysis than those for the three previous regression analyses (1.3423 = one standard deviation).

```
8668= + + + + + + + + + + HULTIPLE REGRESSION + + + + + + + +
6673=
6688=
869# RESIDUAL PLOT.
6766=
                                                                        +250
87:6=
                  Y EST. RESIDUAL -2SD
                                                      1.5
       Y VALUE
£72#=
         6.837
873#=
                   3,969
                             2.868
                                                       1
8748=
         -.362
                    .345
                             -.648
                    .359
875#=
          .783
                              .344
                                                       ī
876#=
          .815
                   -.164
                              .928
                                                       1
£776=
         3.516
                   2.65#
                              .366
878#=
         1.411
                   2.639
                            -1.228
8798=
         2.872
                   1.929
                             .142
                                                       Ι.
                            -1.555
8866=
          1.689
                   3.165
                                                       Ī
881#=
          1.865
                   1.347
                              .458
882#=
          . 285
                   1.215
                             -.93#
          1.844
                             -.267
=8668
                   2.111
6846=
          1.690
                   2.883
                             -.313
885#≠
          1.221
                   1.664
                             -.443
886#=
         2.987
                   1.456
                              .631
887#=
          1.696
                   2.964
                            -1.274
$88#±
          2.836
                   1.157
                               .929
889#=
8988= NOTE - (+) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
891#=
             R INDICATES POINT OUT OF RANGE OF PLOT
892#=
 893#=
8946= NUMBER OF CASES PLOTTED
                                    16.
8958= NUMBER OF 2 S.D. OUTLIERS
                                     1. OR 6.25 PERCENT OF THE TOTAL
896#=
                                            DURBIN-WATSON TEST
8976= VON NEUMANN RATIO
                          2.21191
                                                                 2.67367
898#=
8998= NUMBER OF POSITIVE RESIDUALS
                                       8.
9666= NUMBER OF NECATIVE RESIDUALS
                                       ٤.
9010= NUMBER OF RUKS OF SIGNS
                                       11.
9828=
```

Figure 5
Residuals of the Initial Regression (TOOL)

The final dependent variable to be regressed is Engineering and results in the following regression equation.

```
Ln(ENG) = -11.745 + (.195 Ln(PROTO)) + (.889 Ln(TOGWMAX)) + (1.214 Ln(NZULT)) + (.J96 Ln(TWTAREA)) + (.183 Ln(MAXMACH))
```

The regression equation results in an  $R^2$  = .8619 or 86.19% of the variance of the engineering dependent variable is explained by the independent variables. The calculated F-value is equal to 12.478 which is significant at the .999 level of confidence. The beta values form the following confidence interval at the 95% confidence level (Table 16).

4-14-				
\$16 <b>\$</b> =	AA2551A15W			
	CUEFFICIEN	TS AND CONFI	SENCE INTER	VALS.
3168=		_		
	variable	B	95 PCT	C.I.
9286=				
8218=	PRGTO	.1946	9471	.4363
622 <b>6</b> =	TOCHTAX	.8889	.4615	1.3163
623 <b>6</b> =	NZULT	1.2144	.3120	2.1167
8246=	THTAREA	.0960	1617	.3536
8258=	Makmach	.1829	3123	.6781
<b>8</b> 26 <b>8</b> =	CONSTANT	-11.7449	-17.3164	-6.1734
8278=				

Table 16
Initial Regression Equation Summary (ENG)

The estimated values generated by the regression analysis result in a regression line that predicts the actual values with relatively high accuracy (Figure 6). Even though there are several actuals that are close to two standard deviations from the regression estimates the value of the standard deviation is small (.3557 = one standard deviation).

```
#63#= + + + + + + + + + HULTIPLE REGRESSION + + + + + + + + +
8648=
9659=
$66# RESIDUAL PLOT.
8679=
8688=
       Y VALUE
                 Y EST. RESIDUAL -25D
                                                       6.6
                                                                        +2SD
6698=
           .542
#788=
                     .833
                              -.291
                                                        Ī
8718=
           .698
                     .570
                               .128
                                                        1
                    1.924
8726=
          1.647
                              -.277
                                                        I
8738=
          1.7:6
                    1.996
                              -.288
                                                        I
$749=
          3.466
                    3.193
                               .273
$75#=
          1.459
                    1.228
                               .231
6768=
          1.681
                    2.884
                              -.253
8776=
                    2,348
          2.245
                              -.895
$785=
          2.135
                    2.693
                               .843
8798=
          1.354
                     .784
                               . 228
#8##=
          2.754
                    2.376
                               .377
#8:#=
          1.813
                    2.339
                              -.526
$82#=
          1.953
                    2.281
                              -.328
$83$=
         2.228
                    1.794
                               .426
#34#=
          1.917
                    1.883
                               .#34
8852=
          3.845
                    2.776
                               .268
1866=
6878= NOTE - (+) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
13886:
                R INDICATES POINT OUT OF RANGE OF PLOT
#89#=
8988=
8918: NUMBER OF CASES PLOTTED
                                     16.
6926 NUMBER OF 2 S.B. GUTLIERS
                                                 # PERCENT OF THE TOTAL
                                       # OR
6936=
5946= VON NEUMANN RATIO
                          2.15324
                                            DURBIN-WATSON TEST
                                                                 2.01866
#95#=
8968= NUMBER OF POSITIVE RESIDUALS
                                        9.
8978= NUMBER OF NEGATIVE RESIDUALS
                                        7.
#98#= NUMBER OF RUNS OF SIGNS
                                        8.
4994=
```

Figure 6
Residuals of the Initial Regression (ENG)

### Second Regression

The second step-wise regression is accomplished utilizing the same data base as the initial regression. However, the second regression also utilizes the two artificial variables, TT and MXNZ. These artificial

variables are used as interaction variables. The interaction variables are used to explain some of the variation of the dependent variable that is not already explained by the five independent variables and to control multi-collinearity. From this point forward the initial regression is called REG  $1_r$  and the second regression is called REG 2.

The basis of this section is the comparison of REG 1 with REG 2, in terms of equations, accuracy and significance. The confidence intervals and the residual plots are not presented in this section, but they are contained in Appendix C and D. Again, the analysis process is accomplished by regressing the dependent variable by independent variables. The first dependent variable to be regressed is ODC, and results in the following regression equation.

The REG 2 regression equation generated an  $R^2$  = .9022 and is significant at the .998 level of confidence. In comparison the REG 1 equation generated an  $R^2$  = .889 at the .999 level of confidence. However, the standard deviation for REG 2 is .4812, where the standard deviation for REG 1 is .4585. The small difference of .0227 between standard deviations is not as significant as the 1.2% increase in explained variation, and therefore REG 2 is acceptable. Reviewing the statistics it appears that through the utilization of the artificial variables an increase in variation explained is possible, without a significant decrease in the level of significance or a significant increase in the standard deviation.

The second dependent variable to be regressed is Manufacturing Materials, and results in the following regression equation.

Ln(MANMAT) = -18.2595 + (.0702 Ln(PROTO)) + (1.7978 Ln(TOGWMAX)) + (1.1434 Ln(NZULT)) + (-.2534 Ln(MXMZ)) + (-.0973 Ln(TT)) + (1.0158 Ln(TWTAREA)) + (.9362 Ln(MAXMACH))

The REG 2 regression equation generated an  $R^2$  = .9360, and is significant at .999 level of confidence. In addition, REG 2 developed a standard deviation equal to .2435. REG 2 outperformed REG 1 in all three modes of measurement in this particular case. REG 1 generated an  $R^2$  = .9164, a standard deviation equal to .2489, and was also significant at .999 level of confidence. Clearly, in attempting to estimate manufacturing materials REG 2 with artificial variables is the better regression equation.

The third dependent variable that is regressed is Manufacturing Labor, and results in the following regression equation. Note that only six independent variables are used in the equation, because the seventh variable influenced the degrees of freedom more than it added to the explanation of the dependent variable's variance. The decision to exclude the seventh variable is based upon the decrease in the level of significance and the resulting drop in the adjusted R<sup>2</sup> value.

Ln(MANF) = -7.949 + (1.216 Ln(TOGWMAX)) + (.941 Ln(NZULT)) + (.163 Ln(MAXNZ)) + (-.042 Ln(TT)) + (.054 Ln(PROTO)) + (.410 Ln(TWTAREA))

The REG 2 regression equation generates an  $R^2$  = .899, a standard deviation equal to .2686, and is significant at .999 level of confidence. REG 1 generates an  $R^2$  = .8949, a standard deviation equal to .2599, and is significant at .999 level of confidence. The comparison between REG 1 and REG 2 proves to be inconclusive. The reason is that the increase in explained variation is not highly significant, nor is the increase in the standard deviation. Therefore, either regression equation supplies the same results with the same degree of accuracy.

The fourth dependent variable to be regressed is Tooling Labor, and results in the following regression equation.

Ln(TOOL) = -31.150 + (-3.955 Ln(NZULT)) + (9.757 Ln(MAXMACH)) + (-3.592 Ln(MAXNZ)) + (-.455 Ln(TT)) + (.058 Ln(PROTO)) + (5.115 Ln(TWTAREA)) + (3.589 Ln(TOGWMAX))

The REG 2 regression equation generates an  $R^2$  = .6517, a standard deviation of 1.2606, and is significant at .846 level of confidence. REG 2 outperforms REG 1 in two modes of measurement in the case dealing with the estimation of tooling. REG 1 generates an  $R^2$  = .5064, a standard deviation equal to 1.3423, and is significant at .884 level of confidence. REG 2 provides nearly 15% more explanation of variance, and at the same time reduces the width of the standard deviation. In this particular case, the more accurate regression equation is REG 2 with artificial variables.

The final dependent variable to be regressed is Engineering, and generates the following regression equation.

Ln(ENG) = 2.521 + (.270 Ln(PROTO)) + (-.376 Ln(TOGWMAX)) + (1.177 Ln(NZULT)) + (.137 Ln(TT)) + (-1.469 Ln(TWTAREA)) + (.356 Ln(MXMZ)) + (-.695 Ln(MAXMACH))

The REG 2 regression equation generates an R<sup>2</sup> = .8931, a standard deviation equal to .3498, and is significant at .998 level of confidence. REG 1 for Engineering generates an R<sup>2</sup> = .8619, a standard deviation equal to .3557, and is significant at .999 level of confidence. In analyzing the statistic measures, REG 2 generates a superior performance in the percentage of variance explained, and in a narrower standard deviation. Therefore, REG 2 is the better regression equation when estimating engineering hours for a combination of airframe types. The drop in the level of confidence of .002 is not very significant, when considering that the REG 2 equation is still above .99 level of confidence. Additionally, the increase in explained variation of over 3% more than outweighs the slight decrease in the confidence level.

### Comparison of Parametric Relationships

This section provides a comparison of the hypothesized parametric relationships and the parametric relationships developed by REG 1. The purpose of this section is to strengthen both the hypothesized regression equations and the computer generated regression equations. When logic supports statistics the end result is a higher degree of confidence in the regression equations. The purpose of using REG 1 is that it does not use artificial variables, nor do the logically developed parametric relationships

presented early in this Chapter. It is important to remember that the independent variables in the REG I regression equation are aligned in order of their entrance into the step-wise regression. Therefore, the independent variables are also in order of significance to the regression equation.

The first equation to be compared is Engineering hours. The following equations are first the estimated equation, and second the results of the REG 1 regression (without the beta coefficient values).

EST Eng = Function (TOGWMAX, PROTO, NZULT, TWTAREA, MAXMACH)

REG I Eng = Function (PROTO, TOGWMAX, NZULT, TWTAREA, MAXMACH)

The estimated regression equation and the REG I regression equation are extremely close in the order of entrance of the variables. Therefore, it is logical to accept the validity of REG I. Because REG I executed the variable order extremely close to the hypothesized regression equation, the result adds strength and validity to both the hypothesized and REG I regression equations.

The following is a summarization of the four remaining equations. Note that the hypothesized and REG 1 equations are extremely close in order of entrance, and that the logic of one equation supports and validates the other equation.

EST TOOL = Function (NZULT, TOGWMAX, PROTO, MAXMACH, TWTAREA)

REG 1 TOOL = Function (NZULT, MAXMACH, TOGWMAX, PROTO, TWTAREA)

Performance characteristics dictate their importance by entering first and second in REG 1's regresson equation.

Est MANF = Function (NZULT, TOGWMAX, MAXMACH, TWTAREA, PROTO)

REG I MANF = Function (TOGWMAX, NZULT, MAXMACH, TWTAREA, PROTC)

As indicated, the independent variable TOGWMAX is more significant in the manufacturing equation than had been hypothesized.

EST MANMAT = Function (PROTO, TOGWMAX, TWTAR EA, NZULT, MAXMACH)

REG 1 MANMAT = Function (PROTO, TOGWMAX, NZULT, MAXMACH, TWTAREA)

The performance characteristics play a more important part in explaining variance of the dependent variable than originally thought. This may stem from the majority of the size characteristics being explained by TOGWMAX.

Est ODC = Function (PROTO, NZULT, TOGWMAX, MAXMACH, TWTAREA)

REG 1 ODC = Function (PROTO, TOGWMAX, NZULT, TWTAREA, MAXMACH)

The relative order of entrance of the independent variables remains the same, except the size characteristics enter before the performance characteristics. The order undoubtedly stems from the percentage of variance explained by TOGWMAX compared to NZULT.

#### Factor Grouping Regression

This section is based upon a regression analysis of the factor grouping. Therefore, the data base consists of only the eight fighter airframes. In the process of this analysis two regression runs are accomplished; one using the original five independent variables and another using the five independent variables plus two artificial variables (TT and MXNZ). The first factor group regression is called REG 3, and the second factor group regression with artificial variables is called REG 4. The results of each regression (equation, standard deviation, and significance level) are presented in this section. The actual printouts containing the beta coefficient confidence limits and the residual plots for REG 4 are available for review in Appendix E.

The initial dependent variable to be regressed is Other Direct Charges (ODC), and yields the following regression equations.

REG 3 
$$Ln(ODC) = -9.5736 + (.5919 Ln(PROTO)) + (.9951 Ln(TOGWMAX)) + (.9523 Ln(NZULT))$$

REG 4 
$$Ln(ODC) = -9.574 + (.592 Ln(PROTO)) + (.995 Ln(TOGWMAX)) + (.952 Ln(NZULT))$$

Both REG 3 and REG 4 yield about the same results with an  $R^2$  = .8914, a standard deviation equal to .3907, and are significant at .979 level of confidence. The duplication of regression equations that are limited to three variables indicates that none of the other variables (two independent and two artificial) add to the variation being explained by PROTO, TOGWMAX AND NZULT (Figure 7).

2256=								_	11	1	7		ь	ı	•			_	•	D	=	e	c	•	n	a.									
	* *	* *	•	Ŧ	•	•	Ŧ	п	v	٤	1	ŧ	r	L	E		n	E	v	,	5	3	9	4	U	77	•	•	•	•	•	•	•	•	•
2268=																																			
227#=																																			
2286=	RES:	IDUA	LF	LO	IT.																														
2298=																																			
2366=	Y	VAL	ΙE		Y	E	Ŝī		;	RE!	SI	DU	ΔĹ	-	281	D							1	٥.	8								+2	SB	
231#=	•	••••			•	-		٠	•	_		•	_												-								_		
2329=			17			4.	ŧ					2	53											1											
		4.8						-																				•							
2339=		2.9	31			3.	51	6			-	. F	76										٠	I											
2346=		5.3	71			5.	21	13				.1	67											I											
235#=		4.5	51			5.	23	1			-	ه.	86											1											
2368=		5.3	#1			5.	.15	12				. 1	49											1											
2376=		5.1	65			5.	. 17	8			-	. 8	13											.I											
2386=		5.3	12			5.	.14	8				. 1	64										•	I											
239#=		5.9	<b>9</b> 1			5.	84	6				. #	35											1											
2400=																																			
2416=	NOT	E -	(+)	) ]	NE	10	:AT	ES	3 1	ES'	Ħ	MA	TE	C	ALI	CU	LA'	ľΕ	0 1	WI	IH	H	EA	NS	S	UB	ST	IT	UTI	ED					
2425=		_	Ð	71	in t	CE	TE	e	D	n Ti	NT	n	117	ñ	FI	PΔ	NC:	•	UE	D	ŧ٨	t		_	-										
			n	4.7			116		r	41	n t	v	vi	U	, ,	ner	N. WI	-	٧F	٢	LU	1													
243#=																																			

Figure 7
Regression Analysis of REG 3 (ODC)

The second dependent variable to be regressed is Manufacturing materials, and yields the following regression equation.

Both REG 3 and REG 4 yield the same regression equations. REG 3 and REG 4 results in an  $R^2$  = .9695, standard deviation equal to .1868, and are significant at .987 level of confidence. Note that all five original independent variables are in the equation, but neither of the artificial variables are able to reduce the unexplained variation (Figure 8).

```
4148= + + + + + + + + + NULTIPLE REGRESSION + + + + + + +
415#=
4168=
4176= RESIBUAL PLOT.
4188=
       Y VALUE Y EST. RESIDUAL -250
                                                     4.#
                                                                      +2SD
4198=
4266=
421#=
         4.251
                   4.236
                              .516
4225=
         3.668
                   2.997
                              .fil
                                                      ı.
4236=
                              .641
         4.861
                   4.759
                                                      1.
424#=
         4.662
                   4.503
                              .165
                                                      1
425#=
         4.268
                   4.522
                             -.254
4268=
         3.857
                   3.819
                              .137
427#=
         3.731
                   3.763
                             . #33
428#=
         5.246
                   5.224
                              .522
429#=
4386= NOTE - (+) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
             R INDICATES POINT OUT OF RANGE OF PLOT
4319=
4325=
```

Figure 8

Regression Analysis of REG 3 (MANMAT)

The third dependent variable to be regressed is Manufacturing hours, and yields the following regression equation. Note that both REG 3 and REG 4 are once again the same equation.

REG 3 & REG 4 
$$(Ln(MANF) = -14.13 + (1.184 Ln(TOGWMAX)) + (1.608 Ln(NZULT)) + (.187 Ln(TWTAREA))$$

Both REG 3 and REG 4 result in an  $R^2$  = .8804, a standard deviation equal to .2943, and are significant at .974 level of confidence. Note that

only three of the independent variables are included in the regression equation. The regression equation is limited by choice of the authors, because if the other variables (MAXMACH and PROTO) are included in the equation, the R<sup>2</sup> only increases to .8828 while the standard deviation increases to .412 and the level of significance drops to a .732 level of confidence. In view of these circumstances the equation is limited to three independent variables (Figure 9).

6836= 6846= 6858=	• •	* *	•	•	+	•	+	Ħ	U	L	7	I	P	L	Ε		R	E	C	R	Ε	Ş	S	1	0	N	+	•	ŧ	+	ŧ	ŧ	+	+	•
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Figure 9

Regression Analysis of REG 3 (MANF)

The fourth variable to be regressed is tooling hours, and yields the following equation. Again, note that REG 3 and REG 4 result in the same regression equation.

Both REG 3 and REG 4 result in an  $R^2$  = .8235, a standard deviation equal to .3265, and are significant at .945 level of confidence. Note that only three independent variables are included in the regression equation. Once again, the regression equation is limited to three independent variables, since with the addition of TWTAREA and MAXMACH, the  $R^2$  only increases to .8311 while the standard deviation increases to .4516 and the level of significance drops to a .73 level of confidence (Figure 10).

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8566=
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                                                      . I
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8616=
                              .211
         1.696
                   1.788
8$2$=
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8436=
8848=
         2.587
                   2.612
                              .$75
8656=
         1.696
                   1.639
                              .#51
=8488
         2.836
                   1.945
                              .691
8676=
8888= NOTE - (+) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
             R INDICATES POINT OUT OF RANGE OF PLOT
8595=
8156=
```

Figure 10

Regression Analysis of REG 3 (TOOL)

The final dependent variable to be regressed is Engineering hours, and yields the following equation for both REG 3 and REG 4.

REG 3 & REG 4 
$$(Ln(ENG)) = -11.829 + (1.265 Ln(TOGWMAX)) + (.207 Ln(PROTO)) + (-.405 Ln(MAXMACH))$$

Both REG 3 and REG 4 result in an  $R^2$  = .7874, a standard deviation equal to .3769, and are significant at .922 level of confidence. Again, the authors chose to limit the regression equation to only three independent variables because of the huge drop in the level of confidence. If TWTAREA and NZULT are added to the regression equation the  $R^2$  only increases to .8248, while the level of significant drops to a .718 level of confidence (Figure 11).

981 <b>6</b> =		• •	+ +	•	+ +	H I	U L	Ţ	IF	, F	Ε	R	E	Ç	R	Ε	S	\$	I	0	X	•	•	ŧ	ŧ	ŧ	ŧ	•	ŧ	ŧ
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Figure 11

Regression Analysis of REG 3 (ENG)

# Factor Grouping Summary

The results of the factor grouping regression is promising since several of the  $R^2$  values increased significantly. However, in some cases there is a drop in  $R^2$  value and in the significance level. The drop in  $R^2$  value is not too significant because in all but one case the  $R^2$  is still above

80% explained variation. The drop in level of confidence, which is based on the F-value, is not at all surprising. The reason the level of confidence drops is that the sample size is small (only eight data points). As the data base for fighter airframes increases, the level of confidence will increase accordingly, and the additional independent variables that are not in the proposed regression equations can be added later to increase the percent of explained variation.

## Comparison of the Models

The following section presents a comparison of three models, REG 2, REG 3, and the base model (Grumman). The models are compared on the estimated values that are generated by each model's regression equations. The models are compared in tabular form, which lists the values generated by REG 2, REG 3, the base model, and the actuals. After examining the estimated values for each model, an R<sup>2</sup> is developed for the base model, REG 2 and REG 3.

Since the development of REG 3 was based on only fighter airframes, the comparison is  $\lim_{n\to\infty} \infty$  to only the fighter portion of the data base. The comparison is made using all eight fighter airframe data points. The R<sup>2</sup> values are hand calculated values utilizing the R<sup>2</sup> formula presented in Chapter III. Additionally, all values presented in the table in this section are hand calculated values utilizing the equations identified with the base model in Chapter II, and the REG 2 and REG 3 regression equations developed earlier in Chapter IV.

# **Engineering Hours**

The first dependent variable to be used as a point of comparison is Engineering hours. A summary of the estimated hours are displayed in Table 17. An initial comparison between the base model, REG 2 and REG 3, indicates that REG 3 is a better estimator of the actual values contained in the data base.

	REG 2	REG 3	BASE	<u>ACTUAL</u>
F-1	8.35	5.38	12.66	8.46
F-2	2.32	3.14	3.40	2.73
F-3	9.55	12.26	11.41	15.70
F-4	10.28	9.06	10.83	6.13
F-5	9.65	4.87	9.98	7.05
F-6	7.27	7.68	8.85	9.21
F-7	7.22 ·	7.43	7.10	6.80
F-8	14.31	20.07	11.16	21.00

Table 17

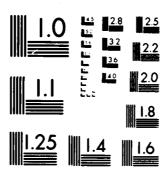
## Comparison of Engineering Estimates

The  $R^2$  value for REG 3 = .8414 as compared to an  $R^2$  = .3235 for the base model, and an  $R^2$  = .543 for REG 2.

# **Tooling Hours**

A summary of the estimated tooling hours are displayed in Table 18. The  $R^2$  value generated for REG 3 is equal to .7813, REG 2  $R^2$  = .2209 and base model  $R^2$  = .0915.

AIRFRAME RDTAE COST ESTIMATING: A JUSTIFICATION FOR AND DEVELOPMENT OF UN. (U) AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL OF SYST. AD-A123 848 UNCLASSIFIED C L BECK ET AL. SEP 82 AFIT-LSSR-56-82 F/G 1/3 NL



MICROCOPY RESOLUTION TEST CHART NATIONAL BUREAU OF STANDARDS 1963 A

	REG 2	REG 3	BASE	ACTUAL
F-1	1.80	4.90	5.49	6.08
F-2	3.00	1.38	1.48	1.33
F-3	13.00	4.67	4.67	6.32
F-4	5.87	5.98	6.04	5.42
F-5	4.77	4.85	5.44	3.39
F-6	2.55	7.14	5.67	8.06
F-7	16.10	5.47	5.17	5.42
F-8	5.49	7.42	2.57	7.65

Table 18

# Comparison of Tooling Hours Estimates

# Manufacturing Hours

A summary of the estimated hours for manufacturing are displayed in Table 19. The generated  $R^2$  value for REG 3, REG 2 and the base model results in a REG 3  $R^2$  = .9498, REG 2  $R^2$  = .866 and base model  $R^2$  = .8469.

	REG 2	REG 3	BASE	ACTUAL
F-1	51.50	55.74	56.19	59.8
F-2	16.00	16.84	16.29	16.5
F-3	68.17	72.75	70.98	82.4
F-4	63.10	61.89	68.26	73.5
F-5	58.00	30.16	62.46	36.9
F-6	26.40	29.34	29.58	34.0
F-7	36.50	29.00	41.52	28.1
F-8	111.05	106.45	102.65	115

Table 19

# Comparison of Manufacturing Hours Estimates

# Other Direct Charges

A summary of the estimated hours for ODC are presented in Table 20. The generated  $R^2$  value for REG 3, REG 2 and the base model results in REG 3  $R^2$  = .8680, REG 2  $R^2$  = .79 and a base model  $R^2$  = .4338.

	REG 2	REG 3	BASE	ACTUAL
F-1	126.97	98.89	173.20	127.35
F-2	17.10	20.20	27.17	18.70
F-3	164.70	181.81	193.22	215.07
F-4	200.00	186.97	203.32	94.70
F-5	171.40	172.77	174.22	200.00
F-6	164.40	177.32	211.01	175.00
F-7	170.37	172.08	171.63	202.80
F-8	243.20	352.80	77.98	365.40

Table 20

# Comparison of ODC Estimates

# Manufacturing Materials

A summary of the estimated hours for manufacturing materials is presented in Table 21. Once again REG 3 is utilized as the comparitor with the base model. The generated  $R^2$  values for REG 3 equals .965, REG 2  $R^2$  equals .93 and the base model again cannot be calculated, which may be due to an error in the equation.

	REG 2	REG 3	BASE	ACTUAL
F-1	73.77	69.13	18.770	70.20
F-2	19.97	20.03	4.839	20.25
F-3	103.20	116.63	23.346	121.60
F-4	93.50	90.29	23.240	105.90
F-5	87.44	92.02	16.600	71.40
F-6	38.44	45.55	10.570	47.30
F-7	52.00	43.07	14.575	41.70
F-8	171.06	185.68	52.990	189.90

Table 21

## Comparison of Manufacturing Materials Estimates

## Verification

At this time, verification of the models developed in this thesis is not possible. The original research plan was to verify the models by attempting to predict the airframe RDT&E costs of the F-18 fighter aircraft. However, this thesis team was unable to collect the required cost data for the F-18 because of an ongoing "should-cost" study. This study made the release of cost data an extremely sensitive issue. Therefore, verification of the thesis generated CERs must be delayed until the necessary cost data is available.

### **Analysis Summary**

The comparison of the three models points to the stated hypotheses in Chapter I that a unique CER exists for each type of airframe (fighter, attack, cargo) for the RDT&E phase of the acquisition process, and that the unique CER's will more accurately prodict RDT&E airframe costs. The

comparison shows that in the area of fighters the best estimator is a CER equation designed specifically for fighter airframes. The REG 2 and base model are fair estimates of fighter airframe dependent variables, but lack the accuracy of the REG 3 equation. Both REG 2 and the base model prove less accurate in estimating fighter airframe costs because both models were developed using fighter, attack, and cargo airframe data. Therefore, REG 2 and the base model are gross estimator models and neither model can consistently estimate a value for fighter, attack, and cargo airframes with a high degree of accuracy. The purpose of REG 2 and the base model is to provide general estimates for a wide variety of airframes.

The REG 3 model, which is specifically designed for a particular airframe, shows consistent results when compared to the actual values. This development suggests promise for generating other specifically designed CER equations, in lieu of general CER equation.

PLEASE NOTE: Pages mis-numbered.

There is no page 85.

(note received with docu.)

#### **CHAPTER V**

## SUMMARY, IMPLICATIONS, AND RECOMMENDATIONS

The purpose of this thesis was to examine existing RDT&E airframe cost estimating models, and to compare the results of a base model with a thesis generated model. The intent was not to discredit any existing model, but to help pave the way to more accurate cost estimating.

# Summary of Methodology and Findings

The methodology utilized in this thesis was first to examine the data base that was to be utilized during the statistical analysis. The data base was initially examined for accuracy and reliability and was found to be the most accurate and reliable available. Next the data was reviewed in terms of logic. The analysis consisted of developing expected logical relationships between the independent and dependent variables. The expected logical relationships were then compared to the computer generated regression equations, and were found to represent logical estimates of the dependent variables.

The first statistical procedure was factor analysis which was used to determine the airframe groupings to be utilized during the regression analysis. The factor analysis indicated that the regression grouping should consist of three distinct groups: one group for fighter, one for attack and one for cargo. The factor analysis developed these groupings based upon the independent parameters of NZULT, MAXMACH, TOGWMAX, and TWTAREA, which represented the size and performance features of the airframes.

Following the factor analysis a regression analysis was conducted on the full data for the fighter, attack, and cargo airframes. This initial regression analysis served as a point of comparison with the base model, and was called REG 1 (Regression analysis one). Next, a second regression analysis (REG 2) was conducted utilizing the full data for fighter, attack, and cargo, but interaction terms were added to the independent variable data set. This second regression analysis resulted in a higher statistical explanation of variance then did the REG 1 analysis. The third regression analysis (REG 3) was conducted utilizing only the data set for fighters. The data set was limited to fighters only based upon the results of the factor analysis. Additionally, a fourth regression analysis (REG 4) was conducted utilizing the fighter data set and interaction terms. Both REG 3 and REG 4 resulted in basically the same regression equations. Therefore, the interaction terms in REG 4 did not explain any more variance than did the initial independent variables.

After the regression analysis had been completed a comparison between the regression equations REG 2, REG 3, and the base model was conducted on the data set for fighters. This comparison was conducted on only the fighter airframes based upon the results of the factor analysis and the fact that REG 3 was based solely on the fighter data set. The comparison indicated that the REG 3 regression equation is a more accurate estimator of the actual fighter dependent variables than either the REG 2 model or the base model.

The statistical procedures support the hypotheses stated in Chapter I, that a unique cost estimating relationship (CER) exists for each airframe group (fighter, attack, and cargo) and that the unique CERs would result in

more accurate cost estimating. This indicates that the development of separate CERs is necessary to more accurately estimate RDT&E airframe costs for the three groups.

## Implications and Recommendations

The implications and recommendations of the research are summarized in four specific ideas. First, accumulate data to further refine the model generated by this thesis team (REG 3). The current REG 3 regression equations are in the state of infancy, and require firm support, so that the equations may become more accurate and verified by the passage of time and test.

Second, accumulate data to generate airframe specific regression equations for both attack and cargo airframes. With a data base of only four, both the attack and cargo data bases are in need of expansion. Once the data base has been developed, airframe specific regression equations may be developed that could possibly be more accurate than the general equations currently utilized to develop cost estimates.

Third, the RDT&E model should be used in conjunction with production and O&S cost models. Several existing models attempt to predict the life cycle cost of a system, but these models lean heavily on the production and O&S phases. While it is true that most of the actual costs occur during the production and O&S phases, most of the design decisions occur during the RDT&E phase of an acquisition. Therefore, Production and O&S models must be successfully meshed with an RDT&E model, so that the influence of a change during the RDT&E phase of a program can be observed in the Production and O&S phases. The process of meshing all three phases into one coherent model can provide the most accurate means in predicting life cycle costs.

And finally, the research initiated by this thesis needs to be expanded, especially dealing with the negative beta coefficients that surfaced in REG 1, REG 2, and somewhat in REG 3. This thesis team examined the relationship by accomplishing a zero line scattergram, in which the data appeared to be randomly distributed around the zero line. This issue was further examined by accomplishing a regression analysis on the data base using the arithmetic values for the independent and dependent variables. This regression analysis still produced negative beta coefficients. Therefore, this thesis team recommends that the data base be examined in detail in an attempt to divulge a latent problem inherent in the data base. This thesis team understands that every data set has some problems, and the data set utilized appears to be the best available. However, the problem of the negative beta coefficients must be examined from every angle.

This problem can possibly by rectified by accomplishing a regression analysis using the factor scores. This methodology would eliminate the multi-collinearity that is contained in the data base, but presents the problem of accurately defining what each factor actually represents in the "real world." The best methodology appears to be a combination of the methodology presented in this thesis accompanied by the aforementioned factor/regression methodology. This would allow for a complete explanation of the negative beta coefficients and perhaps lead to positive identification of the factors developed during the factor analysis.

#### Concluding Remarks

The analysis presented in this thesis represents an initial step in the development of more accurate cost estimating equations for airframe RDT&E costs. The statistical analysis indicates that separate CERs are the

next logical step in developing models with increased accuracy in cost estimating. This logic is contrary to the procedures utilized in previous studies, but is supported by the results of factor analysis and regression analysis.

The accuracy of the CERs of the future are only limited by the inability to obtain verifiable data, and the inability to learn from the previously developed cost estimating equations.

**APPENDICES** 

## APPENDIX A COST AND PERFORMANCE DATA

A A A		6.67	12.5	6.44	25.7		113.0		9.77	59.0	42.0		:	8.60	16.5	82.4	73.5		56.9	34.0	28.1	115.0
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ODC	16.53	00 -	11.87	35.70	100.80	4	498.80	32.08	96	111.20	72.30		127 30	0.00	10.74	213.00	94.70	200.50	37.500	1/2.00	202.80	365.40
ENG	1.72	2 0.1	10.3	5.19	5.56	ć	32.00	4.30	75 7	0.70	9.44		8.46	2 73	77.4	17:70	6.13	7.05	100	17./	08.9	21.00
PROTO	2		٠ ،	×	9	v	`	2	12	77	2		7	0		7 :	16	14	67	; ;	55	18
TOGWMAX	73000	20000	76707	97909	20000	769000	20000	124200	286000		323100		41910	25000	77566	00/7	26000	33000	31276	3000	00766	98850
TWTAREA	3692	1072	2180	7007	2600	33712		8797	1470	61641	14312		2404	2100	3105	2390	7270	1456	2631	2230	077	1190
MAXMACH	1.10	.93	98.	) i	₹.	98.	i	<b>*</b> C.	.50	78	•		2.40	.95	2.30	2,50	0 (	2.10	1.00	2.00		07.7
NZULT	4.00	10.50	9.75		20.73	3.75	,	S. 3	3.75	3,75			12.75	9.00	9.75	11.00		20.11	10.50	9.00	2	00.11
	Attack					Cargo						1	Fighter									

APPENDIX B
FACTOR DATA

FTWTAREA	FNZULT	FMAXMACH FTOGWMAX	FTOGWMAX	ATWTAREA	ANUZLT	ATOGWMAX	ATOGWMAX	CTWTAREA	CNUZLT	CMAXMACH	CTOGWMAX
2404	12.75	2.40	01614	3692	4.00	1.10	7 3000	33712	3.75	98.	769000
2100	9.00	26.	25000	1072	1.05	.93	20000	8797	3.90	. 54	124200
3105	9.75	2.30	72566	2180	9.75	.86	92929	14700	3.75	. 50	286000
2390	11.00	2.50	26000	2600	11.00	. 54	20000	14312	3.75	98.	323100
1456	11.00	2.10	33000	1703	10.50	\$6.	31873	11340	3.00	e0	300800
1692	10.50	1.00	31276	5959	7.50	1.80	62953	3729	3.90	.53	\$ \$000

APPENDIX C
REGRESSION REG 1

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       156=
       166=
170=
186=
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                     VERSION 8.# -- JUNE 18: 1979
       196=
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       210=
       226=
       238: RUN MANE
                           INITIAL REGRESSION
       248= VARIABLE LIST NZULT-MAXMACH-THTAREA-TOGUMAX-PROTO
                           ENG. OBC. MANNAT. TOOL : MANF
       256=
       268: VAR LABELS
                           NZULT ULTIMATE LOAD FACTOR/
       274=
                           MAXMACH MAXIMUM HACH NUMBER/
                           THTAREA TOTAL HETTED AREA/
       226 =
       29#=
                           TOCHMAX MAXINUM TAKEOFF CROSS WEIGHT/
       366=
                           PROTO NUMBER OF PROTOTYPE AIRCRAFT/
       316=
                           ENG ENGINEERING HOURS!
       32#=
                           ODC OTHER DIRECT COSTS/
       336=
                           MANMAT MANUFACTURING MATERIALS/
       34#=
                           TOOL TOOLING/
                           MANF MANUFACTURING HOURS!
       356:
(
                           FREEFIELD
       368= INPUT FORMAT
       378: N OF CASES
                           HANDADAN
       388: COMPUTE
                           ENG=LN (ENG)
       396= COMPUTE
                           ODC=LN(ODC)
       486= COMPUTE
                           TOOL=LN(TOOL)
       410= COMPUTE
                           HANNAT=LN(HANNAT)
       426= COMPUTE
                           MANE-LN (NAME)
                           THTAREA=LN(THTAREA)
       430= COMPUTE
       446: COMPLITE
                           MZULT=LB(MZULT)
       450= COMPUTE
                           HAXMACH=LN (NASHACH)
                           TOCHMAX=LN(TOCHMAX)
       468= COMPLITE
       476= COMPUTE
                           PROTO=LN(PROTO)
       400: RECRESSION
                           VARIABLES-ENG. NZULT: NAXNACH: TVTAREA
       49#=
                           TOCHMAX.PROTO.HANHAT.HANF.TOOL.OBC
                           REGRESSION=ODC WITH WZULT; MAXMACH, THTAREA
       566:
       51#=
                           TOCHMAI.PROTO(1)/RESIB=6
                           RECRESSION=MANHAT WITH MZULT: MAXMACH: THTAREA
       528:
       530=
                           TOCHMAX . PROTO (1) /RESID=0
O
       544:
                           REGRESSION=HAMF WITH NZULT-HAXHACH-TUTAREA
       240
                           TOCHMAI.PROTO(1)/RESID=6
                           REGRESSION-TOOL WITH MZULT-MAXMACH-THTAREA
                           TOCHMAI.PROTO(1)/RESID=6
                           RECRESSION-ENC WITH NZULT-MAXMACH-THTAREA
                           TOCUMAX - PROTO (1) /RESIR = 0
       400- STATISTICS
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       610: READ INPUT BATA
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       438: 88854488 CH HEERED FOR RECRESSION
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       478= END OF FILE ON FILE FAD
       400= AFTER READING 14 CASES FROM SUBFILE NOMANE
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                                              .4871
                                                          16
       900: MAINACH
                             .1526
                                              .5718
                                                          16
C
       818- THTAREA
                                             1.6489
                            8.1946
                                                          16
      826= TOCHMAI
836= PROTO
                                              .9843
                           11.2327
                                                          16
                            1.9866
                                             1.6703
                                                          16
0
       SAGE HANNAT
                            4.8298
                                             .7029
                                                          16
       850= NANF
                            3.7659
                                              .6547
                                                          16
       868= TOOL
                            1.8612
                                             1.5599
0
       876= ODC
                            4.4697
                                             1.1239
       886=
       89#=
(
       966=
       910- CORRELATION COEFFICIENTS.
       928:
       938= A VALUE OF 99.88888 IS PRINTED
      946= IF A COEFFICIENT CANNOT BE COMPUTED.
       954=
Ĺ
       968=
       978: MZULT
                         .66169
       986= MAXMACH
                         .28796
                                   .58154
(
       998= THTAREA
                         .29968
                                  -.4635#
                                            -. 43874
                         .56395
                                  -.77487
      1866= TOCUMAX
                                            -.31386
                                                       .56372
                         .57672
                                                      -.19442
      1618= PROTO
                                   .35366
                                             .45298
                                                                 .58694
      1626= MANKAT
                         .86769
                                   .65781
                                             .43544
                                                       .11842
                                                                 .5247#
                                                                          .59617
                                             .49219
                                                       .16682
      1826s HANE
                         .85294
                                  -. #36#9
                                                                 .59418
                                                                          .52753
                                  -.48633
                                                       .16829
                                                                 .33649
                                                                           .66253
      1646: TOOL
                        -.86627
                                             .87448
(
      1050= 00C
                         .91836
                                   .12783
                                             .39533
                                                       .26288
                                                                 .41684
                                                                           .75913
      1666=
      1676=
                        ENC
                                  NZULT
                                            MAXMACH
                                                      TUTAREA
                                                                TOCHMAX
                                                                         PROTO
      1606:
      1896=
                         .97334
      1100= MANF
                         .19543
                                   .23914
      1118= TOOL
                          .85682
      1128= ODC
                                   .70633
                                             .86864
      1136=
C
      1146=
                        MANNAT
                                  HAN
                                            TOOL
      1150=
      1168=
(
      1176=1INITIAL RECRESSION
                                                     81/14/82 16.33.15. PAGE 3
      1196=
      1196= FILE - MONAME (CREATED - 81/14/82)
      1286=
      1216 a . . . . . . . NULTIPLE REGRESSION . . . . . . . .
      1226-
0
      1216- MEP. WAR... OBC
                                  OTHER DIRECT COSTS
      1246=
      1230- NEAR RESPONSE
                                4.46767
                                             STB. BEV.
                                                            1.12392
0
      1248=
      1278: WARIABLE(S) EXTERED ON STEP 1
                    NUMBER OF PROTOTYPE AIRCRAFT
      1296= PRQTO
0
     1296=
1300= MALTIPLE R
                         .7991 AMOVA
                                             OF SUR SQUARES HEAR SQ.
                         .5743 RECRESSION .7573 RESIDUAL
      1318- R SQUARE
                                                      16.919
                                                                         19.646
                                             1.
                                                             16.919
      1328= STB BEV
                                             14.
                                                       8.629
                                                                  .573 SIG. .861
      1336: ABJ R SOUME .SAGE COEFF OF VARIABILITY
                                                       16.9PCT
      1348=
C
      1350: VARIABLE
                                              F
                                                    SIC.
                                                             BETA ELASTICITY
```

```
1970= PROTO
                        .797
                              .183
                                        19.848 .861
                                                      .75913
     1386= CONSTANT
                      2.891
                                . 488
                                        50.146 .006
     1396=
     1400=
     1418=
     143#=
     1448= VARIABLE(S) ENTERED ON STEP 2
     1450= TOCHMAX MAXIMUM TAKEOFF GROSS WEIGHT
     1446=
     1478: MULTIPLE R
                       .8428 ANGVA
                                         DF SUM SQUARES MEAN SQ.
                                       2.
     1406- R SMIARE
                       .7445 RECRESSION
                                                 14.164
                                                         7.853 18.938
     1496= STB DEV
                       .6103 RESIDUAL
                                         13.
                                                  4.842
                                                            .372 SIC. .800
     1500: ABJ R SQUARE .7852 COEFF OF VARIABILITY
                                                13.7PCT
     1516-
     1529- WARTABLE
                                          F
                                                        BETA ELASTICITY
                              S.E. B
                                               SIC.
0
     1536=
                        .797
     1544: PROTO
                                 .147
                                        29.289 .866
                                                        .75874
                                                                .35297
     1556: TOCHNAI
                        .468
                                 .160
                                         8.558 .012
                                                        .41613 1.:7688
     1566= CONSTANT
                      -2.368
                                1.828
                                         1.679
                                              .218
     1570=11NITIAL REGRESSION
                                                81/14/82 18.33.15. PAGE 4
     1506=
     1598= FILE - NOMAHE (CREATED - 61/14/82)
     1466=
     1618= + + + + + + + + + NULTIPLE REGRESSION + + + + + + + +
     1624=
     1638= DEP. VAR... ODC
                               OTHER DIRECT COSTS
     1444=
     1650= VARIABLE(S) ENTERED ON STEP 3
     1668= NZULT
                    ULTIMATE LOAD FACTOR
     1676=
     1606= MULTIPLE R
                       .9278 ANOVA
                                         DF SUN SQUARES MEAN SQ.
                       .9592 RECRESSION
     1696: R SQUARE
                                         3.
                                                 18.281
                                                           5.427
                                                                  24.418
     1766- STD BEV
                       .4714 RESIDUAL
                                         12.
                                                            .222 SIC. .666
                                                 2.447
0
     1718- ABJ R SQUARE .8241 COEFF OF VARIABILITY
                                                 14.5PCT
     1728=
     1736= VARIABLE
                        8
                                          F
                                                        BETA ELASTICITY
                              S.E. B
                                               SIC.
    1746=
     1750= PROTG
                        .556
                                 .137
                                        16.389 .662
                                                         . 52945
                                                                  .24636
     1768- TOCHMAX
                       1.841
                                 .221
                                        22.197 .661
                                                        .91179
                                                               2.61642
     1776= NZULT
                       1.493
                                 .477
                                         9.784 .669
                                                        .64714
                                                                .67864
     1786= CONSTANT
                     -11.359
                                3.282
                                        12.591 .664
     1796=
     1966:
     1914=
     (:
     1836=
     1846: VARIABLE(S) ENTERED ON STEP 4
     1850= THTAREA TOTAL HETTER AREA
O
     1866=
                                         DF SUM SQUARES MEAN SQ.
     1878= MALTIPLE R
                       .9346 AMDVA
    1909- R SQUARE .8724 RECRESSION 4.
1909- STB BEV .4487 RESIBUAL 11.
1909- ABJ R SQUARE .8261 CREFF OF WARIABILITY
                                                         4.133
                                                16.531
                                                                  18.816
0
                                                  2.417
                                                            .228 SIG. .888
                                                 18.SPCT
     1928: VARIABLE
                              S.E. 1
                                          F
                                               SIC.
                                                        BETA ELASTICITY
     1936=
     1946- PROTO
                        .594
                                        17.717 .001
                                                        .56539
                                 .141
                                                                 .24302
0
     1950- TOCHMAI
                                        14.532 .663
                                                               2.33484
                        .129
                                 .244
                                                         .81339
                                 .477
     1968= NZULT
                       1.442
                                         9.124
                                               .012
                                                         .42488
                                                                 .45534
     1976- THTANKA
                        .154
                                         1.139
                                               .309
                                 .144
                                                        .14392
                                                                 .20273
C
     1900- COUSTANT
                                3.184
                     -11.201
                                        12.443
     1996-11HITIAL RECRESSION
                                                81/14/82 18.33.15. PAGE
     2666e
     2010- FILE - MONAME (CREATES - 01/14/02)
     7878a
```

```
2838= * * * * * * * * * * * * NULTIFLE REGRESSION * * * * * * * * * *
      7444×
      2656= DEP. VAR... ODC
                                  OTHER DIRECT COSTS
      2664=
      2070= WARIABLE(S) ENTERED ON STEP 5
      2006: MAINACH
                    MAXIMUM MACH NUMBER
      2096=
      2166= MULTIPLE R
                         .9429 AMOVA
                                            DF SUM SQUARES MEAN SQ.
      2110- R SQUARE
                          .8898 RECRESSION
                                             5.
                                                               3.369 16.625
                                                     16.846
      2129- STB DEV
                         .4585 RESIDUAL
                                            16.
                                                      2.162
                                                                 .216 SIG. .866
      2136= ABJ R SQUARE .8336 COEFF OF VARIABILITY
                                                    16.3PCT
      2144:
      2150: VARIABLE
                          B
                                             £
                                                   SIG.
                                 S.E. B
                                                             BETA ELASTICITY
      21662
      2176= PROTO
                          .566
                                    .145
                                           16.388 .662
                                                             .53983
                                                                       .25676
      2190= TOCUMAX
                          .848
                                    .247
                                           11.772 .666
                                                             .74291 2.13182
      2196= KZULT
                         1.156
                                    .522
                                            4.963 .651
                                                             .56694
                                                                     .52533
       2200: TUTAREA
                           .212
                                     .149
                                                              .19784
                                              2.423 .195
                                                                        .38867
      2216: MAXMACH
                          .350
                                    . 286
                                            1.495 .249
                                                             .17823 .81196
      2225= CONSTANT
                                  3.223
                       -16.318
                                           16.249 .669
      2236:
      2244:
      2256: ALL VARIABLES ARE IN THE EQUATION.
      2264:
      2276:
      2296=
      2290: COEFFICIENTS AND CONFIDENCE INTERVALS.
      2366:
(
      2318: VARIABLE
                                     95 PCT C.I.
      232#=
      2338= PROTO
                          .5661
                                      .2545
                                               . R774
      2348= TOCHMAN
                          .8483
                                              1.3992
                                     .2974
      2350= NZULT
                        1.1559
                                    -.9672
                                              2.3196
      2368: THTAREA
                         .2126
                                    -.1281
                                              .5441
     2378: MAINACH
                          .2543
                                    -.2995
                                               .9884
     2386: CONSTANT
                      -10.3184
                                  -17.4998
                                            -3.1371
     2394:
     2466±
      2419: VARIANCE/COVARIANCE MATRIX OF THE UNMORMALIZED REGRESSION COEFFICIENTS.
     2428=
     2430=
     2440= NZULT
                        . 27258
     2456= MARMACH
                        -.86699
                                   .00284
C,
     2448= TUTAREA
                        -.01770
                                  .01354
                                            .02221
     2478- TOCUMAN
                        .18294
                                 -.61885
                                           -.81767
                                                      .64113
      2484× PR010
                        -.63116
                                 - . M648
                                            .06382
                                                     -. #1542
                                                               .01955
C
     2496=
     2586s
                       MZUL T
                                MAXMACH
                                          TWTAREA TOGMAX PROTO
     25160
0
     2526-
      2530-11HITIAL RECRESSION
                                                   81/14/82 18.33.15. PAGE 6
0
     2356- FILE - HOMME (CHEATED - 01/14/82)
     EMP . . . . . . . . NULTIPLE REGRESSION . . . . . . .
0
     2599= SEP. WR... 88C
                                 OTHER SINECT COSTS
     2500-
0
     2416=
     2426- SUMMAT TABLE.
     2420-
0
     2440- STEP WARIABLE E/R
                                    MALT-R R-SQ CHANGE R OVERALL F SIC.
     2456-
     2440-
                               19.848 .759 .574 .576 .759
                                                                19.640 .661
C
            2 TOCHMAI
3 W7FB T
                        E
                                8.530 .862 .744 .168
9.784 .927 .950 115
                                                         18,938 .000
179 ...24 A1R . 000
                                                        .411
```

```
1.139 .934 .872 .813 .283
     1698: 4 THTAREA E
                                                          16.516 .500
     2760: 5 MAINACH E
                             1.495 .943 .889 .817 .395 16.825 .666
     2716=1INITIAL REGRESSION
                                               61/14/82 16.33.15.
     2726:
     2730: FILE - NOMAME (CREATED - 01/14/82)
     2750 = + + + + + + + + + + HULTIPLE REGRESSION + + + + + + +
     2766=
     2776=
     2790- RESIDUAL PLOT.
     2798=
     2006=
            T VALUE Y EST. RESIDUAL -258
                                                      6.6
                                                                     +250
     2916s
     2829=
             2.865
                      2.958
                                -.145
     2836=
              2.476
                      2.254
                                .221
     2846=
              3.575
                       4.418
                                -.834
     2856:
                      4.585
                                . #28
              4.613
                      5.775
     2868:
              6.200
                                .434
     2870=
              3.468
                      3.367
                                . 141
              4.711
                      4.577
     2886=
                                .134
     2896=
                               -.577
              4.281
                      4.857
     7966:
              4.847
                      4.711
                                .135
     2916=
              2.931
                      2.868
                                .123
     2925=
              5.371
                       5.211
                                .159
     2936=
              4.551
                       5.267
                                -.717
     294#=
              5.361
                      5.131
                                .170
     2956=
              5.165
                      4.965
                                .266
                      5.683
     2966=
             5.312
                                .229
     2976=
              5.961
                      5.623
                                .278
     2998:
     2996: NOTE - (+) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
     3666:
                 R INDICATES POINT OUT OF RANGE OF PLOT
     3616=
     3626=
C
     3838= NUMBER OF CASES PLOTTED
     3846= NUMBER OF 2 S.D. OUTLIERS
                                       # OR
                                                # PERCENT OF THE TOTAL
     3050=
     3666= VON NEUMANN RATIO 2.43726
                                           DURBIN-MATSON TEST 2.28488
     3676=
     3808- NUMBER OF POSITIVE RESIDUALS
                                       12.
     3090: NUMBER OF NEGATIVE RESIBUALS
                                        4.
     3100= NUMBER OF RUNS OF SIGNS
     3110=
C
     3126- NORMAL APPROXIMATION TO SICH DISTRIBUTION IMPOSSIBLE.
     3139- USE A TABLE FOR EXPECTED VALUES.
     3146=1INITIAL RECRESSION
                                               #1/14/82 18.33.15. PAGE 8
0
     3156=
     3168= FILE - NOMANE (CREATED - #1/14/92)
     3170=
0
     3196-
     3290- MEP. VAR... HAMMAT
                              MANUFACTURING MATERIALS
0
     2210-
     2229- MEAN RESPONSE
                             4.62899
                                                        .78284
                                        STD. NEV.
     2230-
     2246= VARIABLE(S) ENTERED ON STEP 1
     3256- PROTO
                    NUMBER OF PROTOTYPE AIRCRAFT
     2244s
     3270= MALTIPLE R
                       .5%2 MOVA
                                        OF SUN SQUARES NEAM SQ.
                       .3554 RECRESSION
                                               2.634
     3200- R SQUARE
                                         1.
                                                                  7.728
     3296- STB BEV
                       .5041 RESIDUAL
                                                 4.777
                                                           .341 SIG. .615
     3366- ABJ R SQUARE .3694 COEFF OF VARIABILITY
                                                14.5PCT
     3316-
     3328= VARIABLE
                       1
                                         F
                                                       BETA ELASTICITY
                                             212
                             $.E. 1
C
     2220-
```

```
.315 186.754 .600
    3356= CONSTANT
                     3.254
    3344=
    3376=
    3396 =
    3416= VARIABLE(S) ENTERED ON STEP 2
    3428 - TOCHMAS MAXIMUM TAKEOFF CROSS WEIGHT
    1436=
    3446= MULTIPLE R
                     .7938 AMOVA
                                     DF SUM SQUARES MEAN SQ.
                                                      2.335 11.674
    3456: R SQUARE
                     .6361 RECRESSION
                                      2.
                                              4.670
    3460- STB DEV
                     .4592 RESIDUAL
                                     13.
                                              2.741
                                                       .211 SIG. .602
    3470= ABJ R SQUARE .5732 COEFF OF VARIABILITY
                                             11.4PCT
    3499= WARTABLE
                            S.E. B
                                           SIC.
                                                    BETA ELASTICITY
    3500=
    3519= PR0T0
                      .391
                              .111
                                     12.472 .664
                                                    .59566
                                                             .19225
    3528= TOCUMAY
                      .374
                              .126
                                      9.656 .688
                                                    .52414 1.84345
    353# CONSTANT
                     -.95#
                             1.375
                                       .477
                                           . 582
    3546=1INITIAL REGRESSION
                                            #1/14/82 18.33.15. PAGE
    3556=
    3568= FILE - NONAME (CREATED - 81/14/92)
    3576=
    3596=
    3686= DEP. VAR... MANHAT MANUFACTURING MATERIALS
    3628= VARIABLE(S) ENTERED ON STEP 3
    3636= NZULT
                  ULTINATE LOAD FACTOR
    3646=
    3650= NULTIPLE R
                     .9297 ANOVA
                                      DF SUM SQUARES MEAN SQ.
    3666: R SQUARE
                     .8643 RECRESSION
                                                    2.135 25.479
                                      3.
                                              6.485
                     .2895 RESIDUAL
    3678: STD DEV
                                      12.
                                              1.865
                                                        .884 SIG. .886.
    3698= ADJ R SQUARE .8384 COEFF OF VARIABILITY
                                              7.2PCT
    3696=
    3786= VARIABLE
                           S.E. B
                                           SIC.
                                                    BETA ELASTICITY
    3716=
    3728= PROTO
                      .176
                              .884
                                      4,366
                                           . 659
                                                    .26813
    3738: TOCHNAS
                      .984
                              .136
                                     42.639
                                                   1.24875 2.47889
                                           .000
    3740× MZULT
                     1.334
                              .293
                                     28.718
                                           .001
                                                    .92442
                                                           . 67255
    3750: CONSTANT
                    -8.981
                             1.966
                                     28.863 .961
    3748=
    3776=
    3786=
    3866=
O
    3816= VARIABLE(S) ENTERED ON STEP 4
    3828 - MAXMACH
                 MAIIMUM MACH MUMBER
    3636
                                     DF SUM SQUARES MEAN SQ. 4. 6.754 1.689
    3046= MULTIPLE R
                     .9547 ANOVA
     3656= R SQUARE
                     .9114 RECRESSION
                                              4.754
                                                            28.296
     2946- STB DEV
                     .2443 RESIDUAL
                                      11.
                                               .454
                                                        .668 SIG. .888
    2079- ASJ R SQUARE .8792 COEFF OF WARIABILITY
                                               4.1PCT
     2005-
2016- MAIABLE
                                             212.
                                                      META ELASTICITY
                             S.E. B
    2966u
     3916= PROTO
                               .673
                      .134
                                     3,363
                                                     .76449
                                                             . BLLES
                                                            2.34320
    3928: TOCUMAS
                      .848
                              .116
                                     $3,773
                                            .600
                                                   1.18784
                     1.647
                                            .002
                                                             .53015
    3936= HZULT
                              .271
                                     15,535
                                                    .73949
     3948- MAXMACH
                                            .834
                      .350
                              .145
                                     5.450
                                                     .28481
                                                             .81324
     3950= CONSTANT
                    -7.105
                              1.718
                                     21.776
                                            .001
    3968-11NITIAL REGRESSION
                                            $1/14/82 18.33.15. PAGE 18
    2976=
     3900= FILE - HOMANE (CREATED - 01/14/82)
O
```

```
14:4:
     4626= BEP. VAR... MANMAT
                                 MANUFACTURING MATERIALS
     4636z
     4848= VARIABLE(S) ENTERED ON STEP 5
     4858= THTAREA TOTAL WETTED AREA
     4876= MULTIPLE R
                                           DF SUN SQUARES NEAM SQ.
                        .9573 AMOVA
                                                                        F
     4606= R SQUARE
4676= STD DEV
                        .9144 RECRESSION
                                                                     21.924
                                           5.
                                                            1.358
                                                    6.791
                        .2489 RESIDUAL
                                                               .842 SIG. .666
                                           14.
                                                      ,419
     4100- ABJ R SQUARE .8746 COEFF OF VARIABILITY
                                                     4.2PCT
     41162
     4129- WARTABLE
                         8
                                S.E. 8
                                            F
                                                 SIC.
                                                           BETA ELASTICITY
     4120-
0
     4146- PROTO
                         .124
                                  .676
                                           2.658 .135
                                                           .18813
                                                                     .66872
     4158- TOCHMAI
                         .897
                                  .134
                                          44.784
                                                 . 156
                                                          1.25663
                                                                   2.56176
     4146- NEBLT
                        1.117
                                   .283
                                          15.544
                                                 .003
                                                           .77419
                                                                     .56325
0
     4170: MAXMACH
                                  .155
                                           4.827 .873
                        .312
                                                           .25385
                                                                     .#1182
     4186= THTAREA
                        -.842
                                  .601
                                            .596 .458
                                                          -.69321
                                                                    -.12764
     4198= CONSTANT
                                  1.758
                        -8.166
                                          21.436 .661
     4766:
     4216=
     4228= ALL VARIABLES ARE IN THE EQUATION.
     4236=
     4246=
     4250=
     4268: COEFFICIENTS AND CONFIDENCE INTERVALS.
     4278=
     4286: VARIABLE
                                    95 PCT C.I.
     4296=
     4366= PROTO
                                   -. 6454
                         .1236
                                              .2927
                                    .5983
     4316: TOCHMAI
                         .8973
                                             1.1964
     4328= NZULT
                        1.1172
                                     .4858
                                             1.7485
     4336: MAINACH
                        .3126
                                    -.8344
                                             . 6585
     4348: TUTAREA
                        -.6625
                                    -.2427
                                              .1178
0
     435#= CONSTANT
                        -8.1961
                                  -11.9982
                                           -4.2619
     4368=
     4378=
     4300: VARIANCE/COVARIANCE MATRIX OF THE UNMORMALIZED RECRESSION COEFFICIENTS.
     4396=
     1444:
     4410= NZULT
                        .50629
     4428= MAXMACH
                       -.61974
                                  .82418
     4430: TUTAREA
                       -.66522
                                  .86399
                                           .66654
     4446= TOCHMAX
                        .83633
                                 -. 66555
                                          -.96521
     4456: PROTO
                       -.86916
                                 -.66191
                                           .06113
                                                   -.06454
                                                              .00576
     4468=
G
     4476=
                      MZULT
                                MAXMACH TWTAREA TOCUMAX PROTO
     4494:
     4496:
0
     4500-11HITIAL RECRESSION
                                                   #1/14/82 18.33.15. PAGE 11
     4516-
     4526- FILE - NOMANE (CREATED - 81/14/82)
0
     0
     4560- BEP. WAR... NAMMAT
                                 MANUFACTURING NATERIALS
     4576
     4500=
4590= SUMMARY TABLE.
0
     4616- STEP WARIABLE E/R
                                 F MALT-R R-SQ CHANCE R OVERALL F SIC.
0
     4425-
     4436=
            1 PROTO
                                7.725 .5% .355 .355
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                              1.456 .794 .636 .275
28.718 .936 .844 .234
            2 TOCHMAR
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.596 .957 .916 .665 .118 21.924 .666
     4670= 5 THTAREA E
                                                 81/14/82 18.33.15. PAGE 12
     4680=1INITIAL RECRESSION
     4696=
     4700= FILE - NOMANE (CREATER - 81/14/82)
     4714:
     4728= • • • • • • • • • • NULTIPLE REGRESSION • • • • • • •
     4736=
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     4748=
     4756- RESIDUAL PLOT.
     4768=
C
     4776=
            7 VALUE
                     T EST. RESIDUAL -2SD
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     4794-
                       3.099
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     4810-
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     4825=
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     4836=
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     4844:
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     4868=
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     4876=
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     4928=
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     4936=
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     4946=
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C.
     4956=
     4968= NOTE - (+) INBICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
     4976=
                R INDICATES POINT OUT OF RANGE OF PLOT
O
     4988=
     4996=
     5866: NUMBER OF CASES PLOTTED
                                       16.
     SOIS NUMBER OF 2 S.D. OUTLIERS
                                                  # PERCENT OF THE TOTAL
                                        # OR
     5474:
     58382 VON NEUMANN RATIO 2.48519
                                             BURBIN-MATSON TEST 2.25487
     5444:
     5050: NUMBER OF POSITIVE RESIDUALS
     5640: NUMBER OF NEGATIVE RESIDUALS
     5676= NUMBER OF RUMS OF SICHS
     5090= NORMAL APPROXIMATION TO SICH DISTRIBUTION IMPOSSIBLE.
C
     5100: USE A TABLE FOR EXPECTED VALUES.
     5110=1INITIAL RECRESSION
                                                 61/14/82 18.33.15. PAGE 13
     5126=
0
     5130= FILE - NOMANE (CREATED - 01/14/82)
     514#=
     O
     5146-
     .5179- EP. VAR... MAF
                                MANUFACTURING HOURS
     3120
                          3.76596
     SIND WERE RESPONSE
                                                         .65468
                                          STD. DEV.
     3216- WATABLE (S) ENTERED ON STEP 1
0
     5229- TOCHMAI HAXINUN TAKEOFF CROSS WEIGHT
     5230=
     5240= MULTIPLE R
5250= R SQUARE
                        .5842 MICVA
                                          DF SUM SOUMRES MEAN SQ.
0
                        .3413 RECRESSION
                                          1.
                                                   2.194
                                                            2.194
                                                                    7.253
     SZAG- STD DEV
                        .3500 RESIBUAL
                                                   4.235
                                                             .363 SIG. .817
                                          14.
     5270- ABJ R SOURCE .2942 COEFF OF WARIABILITY
                                                   14.8PCT
0
     3796e
     5290= WARTABLE
5300=
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                                                         BETA ELASTICITY
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\mathbf{C}
     5316- TOCHMAI
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5330=
C
    5346:
    5354:
     5376=
     5306= VARIABLE(S) ENTERED ON STEP 2
    5396= NZULT
                  ULTIMATE LOAD FACTOR
    5466=
     S416= NULTIPLE R
                     .8967 AMOVA
                                     DF SUM SQUARES MEAN SQ.
                                                    2.493 22.461
     S428= R SQUARE
                     .7756 RECRESSION
                                    2.
                                             4.986
    5436: STD DEV
                     .3332 RESIDUAL
                                     13.
                                              1.443
                                                       .111 SIG. .600
     5446- ABJ R SQUARE .7410 COEFF OF VARIABILITY
                                            9.SPCT
    5454a
    5460= VARIABLE
                      1
                           S.E. B
                                      F SIG.
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    5478
    5400- TOCHMAX
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                                    25.156 .666
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     5500= CONSTANT -9.540
                             2.026
                                     22.164 .566
    5516=1INITIAL RECRESSION
                                            #1/14/82 18.33.15. PAGE 14
    5528=
    5536= FILE - NONAME (CREATED - 81/14/82)
     5544:
    5544=
     5578= BEP. VAR... MANF
                            MANUFACTURING HOURS
    5586:
     5596= VARIABLE(S) ENTERED ON STEP 3
    5680= MAXMACH MAXIMUM MACH NUMBER
C
    5616=
    5628= MULTIPLE R
                     .9293 ANOVA
                                     DF SUM SQUARES MEAN SQ.
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    563#= R SQUARE
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                     .8637 RECRESSION
    SA48= STB DEV
                     .2702 RESIDUAL
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                                               .876
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     5650: ABJ R SQUARE .8296 COEFF OF VARIABILITY
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    SALE
    5670= VARIABLE
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     5496=
     SANGE TOCUMAI
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     5788= NZULT
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     5716= MAINACH
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     5728= CONSTANT
                    -7.763
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    5736=
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    5750°2
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    5778=
    5796= VARIABLE(S) ENTERED ON STEP 4
G
    5798= TUTAREA TOTAL NETTED AREA
     5966=
                                     DF SUM SQUARES NEAM SQ. F
4. 5.691 1.423 21.215
     SOLG- MULTIPLE R
                     .9489 ANDVA
    SOZO: R SQUARE
                                    4.
                     .8852 RECRESSION
     3836- STB DEV
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     5846- ABJ R SQUARE .8435 COEFF OF VARIABILITY
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    5806= TOCHMAX
5896= MZULT
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    5916- TETAREA
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                    -7.819
     5928- CONSTANT
                                     21.462
                                            .661
     5936-1 INITIAL REGRESSION
                                            #1/14/92 10.33.15. PAGE 15
    3945e
     5950= FILE - MONAME (CREATED - 81/14/82)
0
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     5994x .........
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5996= DEP. VAR... MANE
                                 MANUFACTURING HOURS
     6866 =
     6816= VARIABLE(S) ENTERED ON STEP 5
     6828= PROTO
                     NUMBER OF PROTOTYPE AIRCRAFT
     6030=
      6848= MULTIPLE R
                         .9468 AMOVA
                                            DF SUM SQUARES MEAN SQ.
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      6858= R SQUARE
                         .8949 RECRESSION
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     LOLO: STD DEV
                         .2599 RESIDUAL
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                                                                .968 SIC. .698
     6676= ADJ R SQUARE .0424 COEFF OF VARIABILITY
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      4888±
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     4096= VARIABLE
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     4166=
     6110- TOCHMAI
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      6136- MAKMACH
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      6146= THTAREA
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     6156= PROTO
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      4168= CONSTANT
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      6178=
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     4186=
      6198= ALL VARIABLES ARE IN THE EQUATION.
      4244=
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      4216z
      6226=
      6238= COEFFICIENTS AND CONFIDENCE INTERVALS.
      6246=
      6256= VARIABLE
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      6266=
      6278= TOCHMAX
                          .86#8
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      6286= MZULT
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      6298= MAXMACH
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      6366: TUTAREA
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                                               .#841
      6318= PROTO
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                                     -.1664
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      4328= CONSTANT
                        -7.1673
                                  -11.2376
                                            -3.8978
      6336:
      4346=
      6350: VARIANCE/COVARIANCE MATRIX OF THE UNMORNALIZED REGRESSION COEFFICIENTS.
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      4346s
      6376=
      6306= NZULT
                         .88754
      6396= MATMACH
                        -.02152
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      6466" THTAREA
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      6418= TOCHMAI
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O
      4456=
      ME
      6470=1INITIAL REGRESSION
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                                                                          PACE 16
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      6406=
      6498= FILE - HOHAME (CREATED - $1/14/82)
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      ASIG- . . . . . . . . NULTIPLE REGRESSION . . . . . . .
      4530- SEP. VAR... NAVE
                                  MANEFACTURING HOURS
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      4540=
      4554
      4566= SUMMARY TABLE.
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      4570=
      6500= STEP VARIABLE E/R
6590=
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O
      4480-
             1 TOCHMA
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      4428: 3 MAINACH E
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 6728: PESICUAL FLOT.
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13:2:
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7.48= GEP. 448... TOOL
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7:50=
7168= MEAN PESPONSE
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7176=
7180: VARIABLE(S) ENTERED ON ETER 1
7198= MZULT
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7218# MULTIPLE R
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1. 8.633 3.433
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7.10 R SQUARE
7138= 37D DEV
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                    .0065 REGRESSION
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7148= ALL R SQUARE .1628 COEFF OF VARIABILITY
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7.50=
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   7430= VAR:48.E
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   7450= 42017
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   TOPER *LITTELE R .69F0 AND/4 DF 5L* SQUAREE *ME4.52. F
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7818# ADUR SCUARE .2556 DEFF OF VARIABILITY 72.7F07
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     7860: MAXMAIR
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     7870= "JCm#41
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     7820: PRGT1 .148
7892: UJMSTANT 15.144
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     7988=LINITIAL REGRESSION
                                                                                                                                                            91/14/82 18.33.15. PAGE 28
     . . .
       1928: FILE - NONAME (CREATED - $1/14-52)
     1938:
       TRANSPORT OF THE PROPERTY OF T
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6468= * * * * * * * * * * * * . _ TIPLE REGRESSION * * * * * * * *
6498=
8586= DEP. VAR... TILL
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85: #s
6513:
ERSSE SLAMARY TABLE.
1544:
SSS#: STEP VARIABLE E/R
                                                                  F MULTER RESE CHANGE R GVERALL F 800.
₹* 6##
:570:
                                                                 4.537 .486 .237 .237 -.486
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6568: 2 MAXMADH E
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.464 .712 .586 .823 .168
6600: 4 PROTO
5600: A PROTO E
E 10: 5 TWTAREA E
PATR: TYTTA PROPERTY
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FLACE FOLE - NONAME - COREATED - EDITAVEDA
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8899: RESIDUAL RUM.
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                           : :::
6736=
                 ..53
        -.561
6740=
                           : 46
6753:
                           . . . . 4
         .76.
                 -...24
£758=
         . . . 5
                           . .
£776=
         1.6.5
                 2.:38
        ::-:
675₹:
                 2.5.5
:75::
                 ..;;;
                  ..:
                          -..:::
. 44:
        . . . . .
                 . . . . . .
::.;:
        ...25
                           4.5
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        . . . . .
                           -.::/
        .....
6.73
                           - ...
                 1.881
1 162
        ....
                          - , 44
        1.::•
..4]e
1.::•
८३ ५वे ह
                           . . . .
        . :-è
                         -:.:
55.95
:::2:
                 . . . 3
                           :::
STAGES NOTE - 4 CONCOMMENTED SETTIMATE CALCULATED WOTH MEANS SUBSTITUTED 

STAGES OF SUBSTITUTE STORT OUT OF PANGE OF PLOT
1121
 3418:
PRHAM AUMEER OF CASES FLOTTED 12.1
PREAM NUMBER OF CLEUCY CONCERS 1.1 OR 1 SIGES FERCENT OF THE TOTAL
: 4443
6478# VON VELMANN FATTO - 1,21141
                                    i i
1998: NUMBER OF POSITIVE RESIDUALS
SERRE NUMBER OF RESITIVE RESIDUALS
TRUE NUMBER OF FLANS OF BOOMS.
:3:3:
PREZE NIRMA, AFRETRIMATION TO SIGN DISTRIBUTION IMPOSSIBLE.
PRARM USE A THELE FOR EXPECTED VALUES.
SVERMINITIAL RESPESSION
                                          #30/14/62 18.33..E. F4GE 13
: 444:
RB70= FILE - NGNAME - KOREATEL - 01/14/EL
: ĝ∉:
SIDE DEF. VAR... ENG ENGINEERDAG HOURS
9:28:
9138* MEAN RESERVASE 1,96596 STD. DEV. .75146
9;46=
915## VARIABLE(S) ENTERED ON STEP 1
916#= PROTO NUMBER OF PROTOTYFE AIRCRAFT
9176=
                                   OF SUN SQUARES MEAN SQ.
                                                            e.763
9186= 48277722 3
                 .5787 ANGVA
                                            2.984 2.984
6.177
                                  1. 2.984
14. 6.177
919## R 56.882
                 .3257 RECRESSION
.441 316. .221
9220=
                                    e $10.
                                                  BETA ELASTILITY
9118: VARIABLE
                  6
                         3.E. $
$744:
9259: PROTO
                   .417
                          . . 69
                                   6.763 .821
                                                   .57071 .43141
FLOG= CONSTANT
                 1.691
                           .358
                                   9.168 .669
527ë=
11000
```

```
1744.
41.4:
PRODER WAR CARLESS ENTERED ON STEEL 1
RECAR TOOMPAS PAXINGE TAKEDER DROSS WEDGHT
-8-
. . .
9448: JAR 148LE
                                                  1.€. €
                                                                       -
                                                                                i...
                                                                                                     3574 EL4870007
                                     Ē
94.8=
942#= PR01]
                                                     ...6-- .324
                                                                                                     .5781F .40270
                                                                  11.555 .335
                                                                                                 .fe141 | 1.sic.+
                                                                      :-68:
 PATRICATURE - NOVAME - CREATER - BITCHALLE
 11121
 11361
 FROM DEFINITION OF ENGINEERING HILPS
 4518=
 HEERR WAR CABLERS ENTERED ON STEEL S
FORRENCO UT CONTURBE LOAD FAUTOF
 1749 V 17
 : == ; .
1-33-
 46.80 V46.45L6
                                                                      .
                                                                                                   2274 EL-87007
                                     :
                                                  i.£ :
                                                                                ....
 : ja
                                                     .624 37.465 4888
.045 40.625 71
 4638: 44171
                                   .121
                                                                                                   .1.4.4 .1.74.
...1416 8.7666
                             1.25
 1,48: 7,04:47
9,58: \2.1
                                                                                                       50368 1.475°:
  4688 | DARTANT
                               -.1.114
                                                                      1076=
  :588:
  :6:3:
  . . . . .
 1/108: VARTABLETE ENTERED IN STEF 4
17738: TATHREA TITTAL WETTEL HREA
 : 432
                                   77-8-712 OTHE 7 COST MARKE OF SEPTEMBER 197-8-1-10 
  979#:
                                                                   F SIG. BETA ELASTICITY
  9866: VAR:48.E
                                      £ 9.5. I
 96.4
                                                                                                      .28425
                                                                        3.928 .078
                                                         .:#5
  982#= PRGTG
                                       . 289
                                                                                                     1.17248 5.46614
.84444 1.45342
                                                                    25.::: .262
(68. ::4.8.)
  9630= TOCH#61
                                      .971
                                                       .182
                                  1. 164
  9548= NZ.__
                                                       . 357
                                                                                                       .46584 .26144
  985#= T.TAREA
                                                        .:#8
                                                                        .37: .555
                                     .ĕèc
  F666: DONSTANT
                             -12.274
                                                                       26.576 .886
                                                       2.381
  9570:::NITIAL REGRESSION
                                                                                       21/14/82 18.35.15. FAGE 25
  11111
  959## FILE - NONARE (CREATEL - #1/14/82)
  9966 :
  9918= * * * * * * * * * * * D _ T | F _ E _ REGRESSION * * * * * * * *
   7723=
  FFIRE CEP. VAR... ENG
                                                  ENCINEERING HOURS
   :044:
```

```
FREME VARIABLESS ENTERED IN STEEL 5
MARKE MARKADA - MARIMUM MACH NUMBER
1173:
                                       TF SUM SQLARES MEAN SQL F
SL 7.895 1.879 12.478
18. 1.265 1.27 510. 486
HARRY MUZIFUE A
                  .9184 ANIVA
18.77.7
e 226 =
                                        F $10.
                                                         8874 EL48700.7
8838× V4R148LE
                     Ē
                            S.E. E
3413:
1050: 24171
                    ....
                                        1.1.7 ....
                                                          .20060
                                                         .....
8868= T0Gamax
                     . 55
                                       21,473 .001
                               ...32
                                                         .75:88 1.09428
.10881 .4.074
6678= NZ._-
                                        6.39. .2.E
                    1.214
                               4.
                                       .669 .420
.577 .435
.2861 .88.
BERS THTARES
                    . 5 - -
                               :::
8898: MAXMAC-
                  -11,745
                                                          ..3161
                                                                   1.454
BIBBE CONSTANT
                               1.563
3 3 :
2.23=
BLEAR ALL VAROABLES ARE IN THE EQUATION.
3:42
è:::::
ê. 18°
POTRA COEFFICIENTE AND COMFICENCE INTERNALS.
£ . . . . .
8.98: VARIABLE
                                 95 917 1.1.
                     Ē
1222
11:2: **[*]
                     .::44
                                - ,347;
.45.5
                                           -:::
8228= 1104441
8238= 1211
8148= 1414884
                    ....4
                                          .....
                              .3127 1.1167
1.617 .3516
2.51121 .6751
                    . 3: : 2
                                           . 35 14
815es *41*41-
                  --:
$2:0= 13V5-4:1
                              •: *: •
                                         --.....
2276:
P. D
REFER MARITAGE COMARCANCE MATRIX OF THE CANCEMALICED REGRESSION COEFFICISENTS.
#3êê=
13.8
ELE VILI
BUIBE MAINGI-
                              \mathcal{H}^{\circ}
                   · . r - r . .
PIGE TATUFIA
PUEZ TOGANAT
                                       .0:137
                   · . 6 . 000
                             .20:13
                   - . # . # c .
                                                  .4:077
Alsès FRITI
                   -.0.472 -.00398
                                      .00130 -.00915 .01.77
#37#=
€ : 53=
                  NZ.LT MAXMACH TWTARES TOGMMAX PROTO
435.
6425:
#40#:000014U RE PERSON
                                                #10.4/81 1#.35..5. F40E 18
#####
8438= FILE - NOVAME | ICREATED - 81/14/80:
8443=
#45## # # # # # # # # # MULTERLE REGRESSION # # # # # # # #
6466=
#47#= BEP. VAR... ENG
                             ENGINEERING HOURS
8468=
849#=
8588= SUMPARY TABLE.
85:8=
#52## STEP VARIABLE E/R
                          Fig MULTER RESOLDE-4AGE | R. GVERALL F. EIG.
#53#=
                            £.763 .571 .326 .326 .571
                                                             6.763 .821
1..715 .381
22.234 .268
                           11.565 .802 .643 .317 .564
16.665 .921 .648 .264 .662
8558= 2 TOGNHAX E
8568= 1 NZULT E
8578= 4 TWTARE4 E
                           .371 .923 .853 .865 .386
.677 .928 .661 .869 .288
                                                             15.895 .000
6568= 5 MAXMAGH E
                                                              12.478 .882
#59##::NITIAL REGRESSION
                                                #1/14/82 18.33.15. PAGE 17
41 36 .
```

```
Recar File - Ninabe - Creater - 2, 14 (2)
 P: 18=
 ₽¢4₫:
 86.5
 8068: REDIE AL FLOT.
 1677=
 3003=
        * VALUE | 1 EST. RESIDUAL -181
                                                   0.3
                                                            -188
 1692:
                             - 27
 6788=
 i".):
           . . : :
                    278
          87.ja:
                    1.114
                    . . .
 8738=
 674j=
 $758±
          1.45
 17:d=
           ....
 1771
                             ...
                   2.77
 67:0:
                             .741
          . . . . .
 11.12
 de de
 81.41
          . . . . . .
                             -.51é
 7. ...
          .,₹.
                             - :::
 ille:
          1.117
                             4.
          .....
 2142:
                             .25-
 1552:
 # : · # =
 . . . . .
 994£ =
 ASCAR ALMEER OF CARECULOTTED
BROAR NUMBER OF CIRCUIT COURSE
                                   le.
JOR
                                           A RESCENT OF THE TOTAL
 erie:
 8946: VIN VELMANN RATTS ... 21.77124
                                         ILPEDA-WATERA TEST LIVELESS
 - 12
 BREEN NUMBER OF FIGURIAL REGIONALS
BREEN NUMBER OF NEGATIVE REGIONALS
GREEN NUMBER OF RUNS OF STONE
 . -ê=
 LAND: MORMAL APPROXIMATION TO SIGN COSTRUBUTO MICHPOSSIBLE.
 1818: USE A TABLE FOR EXPECTED VALUES. 1818::CONTROL FERRESCON
                                             #1..4/81 10.00.15. F40E 18
 .2363
 .242=
  ATAR OF TOME RESUSPECT: 14692 SECONCE
 : de 2 =
 :37€:
 . 66.0 =
 1898: TOTAL OF TIME USED ..
                              .5648 SECOVER
 11882
 11:132
 1126=
::36=
 1140: RUN TOMPLETED
 ::50=
 1168: NUMBER OF CONTROL CARDS REACHES
 1178: NUMBER OF ERRORS SETECTED
 .160+5
 119#=+509
 . .£
 MANC- LOCOLT
16.883 323.
                      2:.254 400.
      49.57: SEC.
                    14.675 AL..
                       37.675
 39.675
NAETT TIME 1 HRS. 59 MIN.
```

APPENDIX D
REGRESSION REG 2

```
MAND- E
       HAND/TERMINAL HISMATCH
       HIMAND- EDITOR
       ..F.TAB:1.16
       ..GET.REG2.10-0020
       LE NAME REG2
                              HAS BEEN RETRIEVED
        ..CET.FA3.IB=DOZO
       LE NAME FAS
                             HAS BEEN RETRIEVED
       ..REWIND.SPSS.FA3.REG2
        ..SPSS.D=FA3.I=REC2.LO=ABRV.L=W1.MR
C
0
0
C
         EDIT-W1.S
       ES TRUNCATED- CH# 72 CHARS, LONGEST LINE WAS 75
       ..F,CH=132
       ..EDIT.W1.S
       ..L.A
C
         166=1
        116=S
        128=
                                                                #1/14/82 15.#4.#1. PACE 1
                         VOCELBACK COMPUTING CENTER
        136=
        146=
                         NORTHNESTERN UNIVERSITY
        156:
                        S P S S - - STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES
        178:
        100=
196=
206=
                         VERSION 8.8 -- JUNE 18: 1979
Ü
        21#=
G
        220=
        238= RUN NAME INITIAL RECRESSION
248= VARIABLE LIST NZILT-WAINACH-TUTANEA-TOCUMAI-PROTO
ENG-OBC-MANMAT-TOOL-MANF
                               MZULT ULTIMATE LOAD FACTOR/
MAINACH MAINM NACH NUMBER/
TUTAREA TOTAL WETTED AREA/
        260- WIR LABELS
        0
                                TOCHNAI MAIIMAM TAMEOFF CROSS WEIGHT!
                                PROTO RUMBER OF PROTOTTPE AIRCRAFT/
ENG ENGINEERING HOURS/
OCC OTHER BIRECT COSTS/
0
        316-
                                MANNAT MANUFACTURING MATERIALS/
                                TOOL TOOLING!
                               HANF MANUFACTURING HOURS/
FREEFIELD
        368= IMPUT FORMAT
        379= N OF CAGES
306= CONFUTE
390= CONFUTE
406= CONFUTE
ALAs COMPUTE
0
                                DIE-LINE)
                                88C=LR(88C)
(
                                TOOL=LH(TOOL)
```

```
428: COMPUTE
                           MANF=LN(MANF)
       436: COMPUTE
                           THTAREA=LN(THTAREA)
       448: COMPUTE
                           NZULT=LN(NZULT)
       450 = COMPUTE
                           HARMACH=LN (NAXMACH)
       468= COMPUTE
                           TOCUMAX=LN(TOCHMAX)
      476: COMPUTE
                           NINZ=MAXMACHONZULT
       404: COMPLITE
                           TT=TOCHMAX+TUTAREA
       496= COMPUTE
                           PROTO=LN (PROTO)
       500: RECRESSION
                           VARIABLES-ENC. TOOL . MANF . MANMAT. ODC . MXMZ. TT. PROTO
       516=
                           THTAREA-MAXMACH-MZULT-TOGHMAX
C
       528=
                           REGRESSION=ODC WITH MXMZ-TT-PROTO-TOGMAX-THTAREA
       530=
                           MAXMACH.NZULT(1)/RESID=6
                           RECRESSION=TOOL WITH MXMZ-TT-PROTO-TOCHMAX-THTAREA
0
       224:
                           MAXMACH.NZULT(1) /RESID=6
                           RECRESSION=MANE WITH MINZ, TT, PROTO, TOCHMAY, THTAREA
       576=
                           MAIMACH-MZULT(1) /RESID=#
C
       504:
                           REGRESSION=MANMAT WITH MINZ, TT. PROTO, TOGUMAX, THTAREA
       594=
                           MAXMACH.NZULT(1)/RESID=#
                           RECRESSION=ENG WITH MINZ.TT.PROTO.TOGUMAX.THTAREA
       666 ×
                           MAXMACHINZULT(1)/RESID=6
       616=
       626= STATISTICS
                           ALL
       636= READ INPUT DATA
       656= 66654766 CM NEEDED FOR REGRESSION
       668=
(
       678=
       686=
       696= END OF FILE ON FILE FAS
•
       700= AFTER REABING
                             16 CASES FROM SUBFILE NONAME
       710-11NITIAL RECRESSION
                                                       61/14/82 15.64.61. PAGE 2
       725=
       738= FILE - MONAME (CREATED - 81/14/82)
       750= * * * * * * * * * NULTIPLE REGRESSION * * * * * * *
       768=
       776=
       786: VARIABLE
                                HEAN
                                        STANDARD DEV
                                                          CASES
       794=
       866: ENG
                             1.9659
                                                .7815
                                                             16
       81#= TOOL
                             1.8612
                                               1.5399
                                                             16
C
       826= MANF
                             3.7659
                                                .6547
                                                             16
       835= MANNAT
                             4.6296
                                                .7029
       848= OBC
                             4.4697
                                               1.1239
                                                             16
C
       858= HINZ
                              .4418
                                               1.2300
                                                             16
       868= TT
                            92.5936
                                              18.4892
                                                             16
      876: PROTO
                             1.9966
                                               1.6763
                                                             16
O
       896 - THTAREA
                             8.1946
                                               1.6489
                                                             16
      896= MAXMACH
                              .1524
                                                .5718
                                                             16
       906: NZULT
                             2.0313
                                                .4871
0
       118- TOCUMAX
                            11.2327
                                                .9843
0
       498- CORRELATION COEFFICIENTS.
0
      978= A VALUE OF 99.80005 IS PRINTED 988= IF A COEFFICIENT CANNOT DE COMPUTED.
0
     1800-
      1818- TOOL
                         -,68427
      1020- MANF
1030- MANNAT
                           .85294
                                     .23914
                           .86749
                                    .19543
                                               .97334
      1848= DOC
                          .71836
                                     .8484
                                                         .05402
                                               .70633
      1656= MINZ
                                     .04871
                                               .45437
                           .22276
                                                         .47931
                                                                   .42501
      1868- TT
                           .4476
                                     .23258
                                               .22153
                                                         .2445
                                                                   .32659
                                                                           -.46262
                                                          9M17. . _ 279/1
                          ...52622
                                              ....57772
```

```
.29968
     1886: "H"AREA
                                          .16682
                                .16829
                                                                    -.45168
                                                   .11642
                                                            .20288
     1898= MAXMACH
                                .87448
                        .28785
                                          .46219
                                                   .43544
                                                            .39533
                                                                     . 98698 -
     :100= NZULT
                        .66169
                                -. 48633
                                         -.83689
                                                   .65781
                                                            .12763
                                                                     .52216
     1116- TOCHMAN
                        .56395
                                 .33688
                                          .58418
                                                   .52478
                                                            .41604
                                                                    -.24212
     112#=
     1136=
                      ENC
                                TOOL
                                                  HANNAT
                                                           ODC
                                                                    MXMZ
     ::46=
     1150=
     1146= PROTO
                       -.14620
     1176= TUTAREA
                       .92333-
                                -.19442
     1186= MAXMACH
                       -.41839
                                .45298
                                         -.43674
                       -.66253
     1196= NZULT
                                                   .58154
                                         -.46356
                                 .35366
     1206- TOCUMAI
                                          .56372
                        .23369 -
                                 .56694
                                                  -.31386
                                                           -.77487 •
     1216:
     1226:
                      П
                                PROTO
                                         TWTAREA
                                                  MAXMACH
                                                           NZULT
     1230=
     1246=
     1250=LINITIAL REGRESSION
                                                 61/14/82 15.64.61.
                                                                      PAGE
     126#=
     1278= FILE - NOMAME (CREATED - 81/14/82)
     1286=
     1298= + + + + + + + + NULTIPLE REGRESSION + + + + + + +
     1366s
     1316= DEP. VAR... ODC
                               OTHER DIRECT COSTS
     1326=
     1330: MEAN RESPONSE
                             4.46969
                                         STE. DEV.
                                                        1.12392
     1356= VARIABLE(S) ENTERED ON STEP 1
     136#= PROTO
                    NUMBER OF PROTOTYPE AIRCRAFT
     1376=
                       .7591 ANGVA
    1380: MULTIPLE R
                                         DF SUM SQUARES MEAN SQ.
     1398= R SQUARE
                        .5763 RECRESSION
                                         1.
                                                  10.919
                                                           18.919
                                                                    19.646
     1460: STD DEV
                       .7573 RESIDUAL
                                         14.
                                                  8.829
                                                             .573 SIG. .661
     1416= ABJ R SQUARE .5466 COEFF OF VARIABILITY
                                                  16.9PCT
     142#=
     1436= VARIABLE
                               S.E. B
                                          F
                                                SIG.
                                                        BETA ELASTICITY
     1446z
     1456= PROTO
                        .797
                                        19.846 .861
                                  .183
                                                         .75913
                                                                 .35315
     1460: CONSTANT
                       2.891
                                  . 440
                                         54.144
     1476=
     1494:
     1496=
     1516=
     1528= VARIABLE(S) ENTERED ON STEP 2
     1536= TT
C
     1546:
     1550: MULTIPLE R
                        .8756 ANOVA
                                         DF SUM SQUARES MEAN SQ.
                        .7666 RECRESSION
                                                                   21.356
     1548= R SQUARE
                                         2.
                                                 14.526
                                                           7.263
0
     1576- STD DEV
                        .5833 RESIDUAL
                                                             .346 SIC. .866
                                         13.
                                                  4.422
     1500- ABJ R SQUARE .7307 COEFF OF VARIABILITY
                                                 13.6PCT
     1396-
     1400- VARIABLE
                               S.E. B
                                          F
                                                SIC.
                                                         BETA ELASTICITY
     MIF
     1426- PROTO
                        .845
                                        34,975
                                  .142
                                               . 666
                                                          .82348
                                                                  .38314
0
                                         16.461 .666
.162 .755
     1436- TT
                        .$27
                                                                  . 55534
                                  . 668
. 843
                                                         .44166
     1646= CONSTANT
                         .273
     1450-11NITIAL RECRESSION
                                                 61/14/82 15.64.61.
                                                                   PACE
O
     1446-
     1678= FILE - HONANE (CREATED - $1/14/82)
     1480=
0
     1700=
     1716- DEP. VAR... DEC
                                OTHER DIRECT COSTS
C
     C__QTT2 MA FORTTWO ISTO MATERIA .....
```

```
1746= MXNZ
(
     1750=
                                         DF SUM SQUARES MEAN SQ.
     1766: MULTIPLE R
                       .9161 ANOVA
                                                         5.366 26.675
                       .8392 REGRESSION
     1776= R SQUARE
                                        3.
                                                15.961
     1786= STB DEV
                       .5039 RESIDUAL
                                         12.
                                                 3.647
                                                           .254 SIG. .888
     1796= ABJ R SQUARE .7996 COEFF OF VARIABILITY
                                                 11.3PCT
     1866:
     1816= VARIABLE
                       3
                              S.E. B
                                               SIC.
                                                        BETA ELASTICITY
     1920=
     1836= PROTO
                        .722
                                 .137
                                        27,568 .666
                                                        .68717
                                                                 .31967
C
     1846= TT
                                        19.111 .661
                                                        .55337
                                                                 .69684
                        .634
                                . 648
     1850= HENZ
                        .299
                                        5.417 .838
                                                        .32911
                                                                 . #3485
                                .128
     1846= CONSTANT
                                         .675 .769
                       -.212
                                .774
0
     1974=
     1004
     1294.
O
     1928= VARIABLE(S) ENTERED ON STEP 4
     1936= MZULT
                    ULTIMATE LOAD FACTOR
     1946=
     1958- MULTIPLE R
                       .9236 ANOVA
                                         DF SUN SQUARES HEAN SQ.
     1966= R SQUARE
                       .0536 RECRESSION
                                         4.
                                                 16.162
                                                          4.841
                                                                 15.953
                       .5033 RESIDUAL
                                                 2.786
     1978= STB DEV
                                         11.
                                                           .253 SIC. .666
     1986= ADJ R SQUARE .7995 COEFF OF VARIABILITY
                                                 11.3PCT
     199#=
     2666= VARIABLE
                              S.E. B
                                         F
                                               SIG.
                                                        BETA ELASTICITY
     2818=
C
     2020= PROTO
                        .691
                                 .141
                                       24.139 .866
                                                        .65778
                                                                 .38666
                                                        .64815
     2636= TT
                        .#39
                                .616
                                        17.565
                                               .662
                                                                 .81619
     2646= MXNZ
                        .264
                                 .133
                                        3.948
                                               .072
                                                        .29857
                                                                 .02724
     2656= MZULT
                        .399
                                .393
                                         1.636
                                               .332
                                                        .17293
                                                                 .18135
     7646: CONSTANT
                     -1.478
                                         1.614 .336
                                1.468
     2076=1INITIAL RECRESSION
                                               #1/14/82 15.#4.#1. PAGE 5
C
     2686=
     2898= FILE - NONAME (CREATED - 61/14/82)
     2196:
     212#=
     2130= DEP. VAR... DDC
                               OTHER DIRECT COSTS
     2144:
     2150= VARIABLE(S) ENTERED ON STEP 5
     2144= THTARFA
                   TOTAL METTER AREA
     2176:
     2199= MULTIPLE R
                       .9472 MIDVA
                                         DF SURI SQUARES HEAM SQ.
                                                          AN SQ. F
3.466 17.446
     2190= R SQUARE
                       .8972 RECRESSION
                                         5.
                                                 16.999
0
     2266: STD DEV
                       .4414 RESIDUAL
                                                 1.949
                                                           .195 SIG. .600
     2219= ADJ R SQUARE .8457 COEFF OF VARIABILITY
                                                  9.9PCT
     2224:
0
     2236- VARIABLE
                                         F
                                                        BETA ELASTICITY
                        R
                              S.E. B
                                               SIC.
     2240-
     2250a 20010
                        .414
                                 .129
                                        22.928
                                               .861
                                                        .59417
                                                                 .27268
                                                       1.58836
     2266= TT
                                                                1.89936
                        .972
                                 .027
                                        11.897
                                               .664
     2276- NENZ
                        .144
                                 .136
                                         1.218
                                               .2%
                                                        .15818
                                                                .61483
     2206- MZMLT
                       1.092
                                 .486
                                         5.176
                                                        .47344
                                                                 .49649
                                               ,665
     2296- TUTAREA
                       -.841
                                         4.2%
                                                       -.78493 -1.54265
     2306= CONSTANT
                       -.432
                                1.351
                                          .218
                                               .430
     2316=1 INITIAL RECRESSION
                                                61/14/02 15.64.61.
0
     2328=
     2330= FILE - HORANE (CREATED - 81/14/82)
     2346=
O
     2350= + + + + + + + + + NULTIPLE REGRESSION + + + + + +
     2344
     2376= DEP. WR... 88C
                               OTHER BIRECT COSTS
     7796: WARTON FIRL ENTERFR ON STEP _4 .....
```

```
2466= MAXMACH MAXIMUM MACH NUMBER
     241#=
     2420= MULTIPLE R
                       .9494 MIOVA
                                         DF SUM SQUARES MEAN SQ.
                                                           2.848 13.778
     2430= R SQUARE
                       .9618 RECRESSION
                                                  17.687
                                          6.
     2446= STD DEV
                       .4548 RESIDUAL
                                                  1.861
                                                             .207 SIG. .666
     245#= ADJ R SQUARE .8343 COEFF OF VARIABILITY
                                                  16.2PCT
     2460=
     2476= VARIABLE
                        3
                              S.E. B
                                          F
                                               SIG.
                                                         BETA ELASTICITY
     2406=
     2496= PROTO
                        .416
                                 .133
                                        21.149 .881
                                                         .58147
                                                                  .27631
     2506= TT
                        .#67
                                 .#28
                                         9.255 .814
                                                        1.42491
                                                                1.79435
     2516- NINZ
                        .418
                                 .741
                                          .694
                                                .426
                                                         .69671
                                                                  .#6381
                                 .584
     2528: NZULT
                       1.155
                                         5.247
                                                .#48
                                                         .56663
                                                                   .52566
     2536= TUTAREA
                       -.739
                                 .447
                                         2.733 .133
                                                        -.68929 -1.35416
     2546= MAINACH
                      -1.645
                                1.687
                                                        -.53160
                                          .423 .532
                                                                -.93567
     2556: CONSTANT
                      -1.178
                                1.626
                                          .525 .487
     2540=1INITIAL REGRESSION
                                                01/14/62 15.64.01.
                                                                     PACE
     2588= FILE - NONAME (CREATED - $1/14/82)
     2596=
     2416=
     2620= DEP. VAR... ODC
                               OTHER DIRECT COSTS
     2630=
     2648= VARIABLE(S) ENTERED ON STEP 7
     2656= TOCHMAI
                   MAIIMUM TAKEOFF GROSS WEIGHT
     2670= MULTIPLE R
                       .9499 ANOVA
                                         DF SUM SQUARES MEAN SQ.
(
     2690= R SQUARE
                        .9022 RECRESSION
                                         7. 17.696
                                                          2.442
                                                                  18.547
                        .4812 RESIDUAL
     2696= STB BEV
                                                  1.853
                                          8.
                                                             .232 SIC. .862
     2786= ADJ R SQUARE .8167 COEFF OF VARIABILITY
                                                  18.8PCT
     2718=
     2728= VARIABLE
                        3
                              S.E. B
                                          F
                                                SIG.
                                                         BETA ELASTICITY
     2736=
C
     2746= PROTO
                        .426
                                        15.816 .865
                                                         .59596
                                 .162
                                                                   .27721
     275#= TT
                        .116
                                          .798
                                                .398
                                                        1.86754
                                                                2.27618
                                 .123
     2766= MINZ
                        .488
                                          .634
                                                         .75843
                                                                   .07112
                                 .864
                                                .449
     2776= NZULT
                       1.136
                                 .549
                                                .874
                                                         .48975
                                         4.238
                                                                  .51359
     2796= THTAREA
                                                .502
                                                        -.93369 -1.83436
                      -1.561
                                1.423
                                          .494
     2796= MAINACH
                      -1.212
                                1.965
                                          .465 .542
                                                        -.61673
                                                                -.94139
     2000: TOCHNAY
                       -.228
                                1.168
                                          .038 .856
                                                        -.19963
                                                                 -.57284
     2818= CONSTANT
                       1.397
                                13.264
                                          .611 .919
     2820=
     2836=
     2846= ALL VARIABLES ARE IN THE EQUATION.
     2856=
C
     2948=
     2876=
     2006- COEFFICIENTS AND CONFIDENCE INTERVALS.
0
     2896=
     2900- WARIABLE
                        1
                                   95 PCT C.I.
     2718=
2728= PROTO
2708= TT
0
                        .4258
                                   .2533
                                             .9983
                        .1099
                                  -.1737
                                            .3934
     2900- 1887
2950- HZULT
                        .1003
                                  -1.3643
                                           2.4000
0
                       1.1361
                                  -.1357
                                           2.3959
     2960- TUTAREA
                      -1.0005
                                 -4.2824
                                           2.2814
     2976- MAXMACH
                      -1.2122
                                  -5.441
                                           3.1797
0
     2906- TOCHNAY
                       -.2279
                                  -2.9223
                                          2.4664
     2996= CONSTANT
                       1.3675
                                 -27.1990
                                         31.9748
     3010=
     3828- VARIANCE/COVARIANCE MATRIX OF THE UNMORNALIZED REGRESSION COEFFICIENTS.
     3635-
C
```

```
3868= TT
                                  .61512
                        .03526
     3678= PROTO
                        .$1847
                                 . 66836
                                           .02639
     3696= TOCHMAI
                       -.42337
                                -.13936
                                                   1.36514
                                          -.69336
                                                   1.56843 2.62548
     3696: THTAREA
                       -.32988
                                -.17358
                                         -.09115
                                -.#8823
                                                   1.00210
                                                             .86771
     3166: NATHACH
                      -1.62275
                                         -.65367
                                                                      3.62727
     3110= MZULT
                       -.00328
                               -.86412
                                         -.83652
                                                    .15646
                                                              .02852
                                                                      -.66323
     3126=
     313#=
                      HINZ
                               11
                                         PROTO
                                                  TOGUNAX TUTAREA
                                                                     MAXMACH
     3146=
     3150=
     3166= MZULT
                        .35132
     3176=
                      NZULT
     3186-
     3196=
     22 64a
     3216-11HITIAL RECRESSION
                                                  #1/14/82 15.#4.#1. PAGE 6
     3220 z
     3236= FILE - NONAME (CREATEB - 61/14/82)
     3246=
     3256= + + + + + + + + + NULTIPLE REGRESSION + + + + + + + +
     3268=
     327#= DEP. VAR... ODC
                                OTHER DIRECT COSTS
     3286=
     3296=
     3366= SUMMARY TABLE.
     3316:
                                F MULT-R R-SQ CHANGE R OVERALL F SIG.
     3326= STEP VARIABLE E/R
     3336=
                                                              19.848
     3340=
            1 PROTO
                               19.646 .759 .576 .576 .759
     3350=
                               18.681 .876 .767
                                                 .196
                                                      . 321
                                                              21.358
     3366=
           3 MINZ
                               5.417 .916 .839
C
     3376=
            4 MZULT
                               1.430 .924
                                           .853 .014
                                                      .128
                                                              15.953 .666
                               4.296 .947 .897 .844 .283
     3390=
            5 THTAREA
                       Ε
                                                              17.446 .666
            6 MAXMACH
7 TOCHMAX
                       Ē
     3396=
                                .423 .956 .962 .565 .395
                                                              13.778 .666
C
                                                      .411
                                                              10.547 .662
     3466=
                                 .638 .956 .962 .666
     3418=1INITIAL REGRESSION
                                                  81/14/82 15.64.61.
                                                                       PACE
     3426=
     3436= FILE - NOMAME (CREATED - $1/14/82)
     3448=
     3450= + + + + + + + + + HULTIPLE REGRESSION + + + + + + +
     3446=
     3470=
     3486= RESIDUAL PLOT.
     349#=
            Y VALUE
                     Y EST. RESIDUAL -2SD
                                                         4.6
                                                                          +2SD
     3566=
     3516=
C
     3520=
              2.885
                        2.699
                                                          ī
     3536=
              2.476
                        2.349
                                  .184
              3.575
                        4.359
                                  -.734
0
              4.613
                        4.397
                                  .216
     2560-
                        5.939
              4.290
                                  .249
                        3.474
              3.468
                                  -.864
0
                        4.553
                                  .159
              4.711
                        4.886
4.844
              4.281
                                 -.524
              4.847
                                   .683
0
                        2.839
     3616=
              2.931
                                   ...72
     3428=
              5.371
                        5.184
                                  .267
                        5.364
5.144
              4.551
                                  -.753
O
              5.301
                                  .157
     3456=
              5.145
                        5.102
                                  .643
              5.312
                        5.138
                                  .174
     3448-
C
     3478=
                        5.414
                                   .467
     3486*
     3690= NOTE - (4) INDICATES ESTIMATE CALCULATED WITH HEARS SUBSTITUTED
C
                  R INDICATES POINT OUT OF MANCE OF PLOT
     2766=
     37164
```

```
3720=
    3738= NUMBER OF CASES PLOTTED
                                      # OR
    3740: NUMBER OF 2 S.D. OUTLIERS
                                               & PERCENT OF THE TOTAL
    375# 2
                                          DURBIN-HATSON TEST 2.39786
    3766= VON NEUMANN RATIO 2.55766
    3776=
    3790: NUMBER OF POSITIVE RESIDUALS
    3796= NUMBER OF MEGATIVE RESIDUALS
     3800 = NUMBER OF RUMS OF SIGNS
    3016=
    3828= NORMAL APPROXIMATION TO SIGN DISTRIBUTION IMPOSSIBLE.
     3836* USE A TABLE FOR EXPECTED VALUES.
    3946-1INITIAL RECRESSION
                                              81/14/82 15.64.61. PAGE 18
0
    3854=
     3868= FILE - NONAME (CREATED - $1/14/82)
    3876=
C
    3896 - . . . . . . . . . . HULTIFLE REGRESSION . . . . . .
     3896=
     3966= BEP. VAR... TOOL
                              TOOLING
    3928= HEAN RESPONSE
                          1.06119
                                       STD. DEV.
                                                     1.55994
    3936=
    3948: VARIABLE(S) ENTERED ON STEP
    395#= NZULT
                 ULTIMATE LOAD FACTOR
    304#=
    3978= MULTIPLE R
                                       DF SUM SQUARES MEAN SQ.
                     .4863 ANOVA
                                                      8.633
     3986= R SQUARE
                      .2365 REGRESSION
                                       i.
                                               8.633
                                                                4,337
    3996= STD DEV
                    1.4189 RESIDUAL
                                       14.
                                               27.966
                                                        1.991 SIG. .#56
    4996= ADJ R SQUARE .1828 COEFF OF VARIABILITY 78.3PCT
     4516:
     4828= VARIABLE
                             S.E. B
                                        F SIC.
                                                      BETA ELASTICITY
C
     4636=
     4646= NZULT
                     -1.558
                                .748
                                       4.337 .656
     4856= CONSTANT
                      4.965
                              1.566
                                      16,134 .667
C
    4646=
     4676=
     1486:
     4156=
     4116= VARIABLE(S) ENTERED ON STEP 2
     4126= MAINACH
                  MAXIMUM MACH MUMBER
     413#=
     4148= MULTIPLE R
                     .4553 ANGVA
                                       DF SUN SQUARES MEAN SQ.
                      .4294 RECRESSION
     4150= R SQUARE
                                               15.674 7.837
                                                               4.892
                                       2.
                    1.2657 RESIDUAL
                                                         1.682 SIG. .826
     4166= STD DEV
                                               28.827
                                       13.
     4176= ADJ R SQUARE .3416 COEFF OF VARIABILITY 76.3PCT
(
     4186:
     4198= VARIABLE
                       В
                             S.E. B
                                        F
                                             SIC.
                                                      BETA ELASTICITY
      4286=
0
     4216= NZULT
                     -2.563
                                .825
                                       9.657 .568
                                                     -.88636 -2.89655
     4226- MAXIMICH
                     1.473
                               .763
                                       4.395 .656
                                                      .53989
                                                              .12478
     4236- CONSTANT
                      6.793
                                      16.979 .001
                               1.646
0
     4246-11HITIAL RECRESSION
                                              $1/14/82 15.64.81. PAGE 11
     4234
     4246- FILE - HOMANE (CREATED - $1/14/82)
     4276:
     1296-
     4300= BEP. WAR... TOOL
     4316=
     4328- WARIABLE(S) ENTERED ON STEP 3
C
     4336: NYNZ
     4340=
     4250= MALTIPLE R
                      .7244 AMOUA
                                       DF SUM SQUARES MEAN SQ.
C
                                                      6.419
                     .5276 RECRESSION 3. 19.258
1.1987, RESIDUAL 12. 17.243
     4346- R SQUARE
                                                                 4.467
     4378: STB REV
                                                        1 432 516 475
```

```
4388= ADJ R SQUARE .4895 COEFF OF VARIABILITY 66.6PCT
     4396=
     4466= VARIABLE
                                         F
                                                       BETA ELASTICITY
                       2
                             S.E. B
                                              SIC.
     4418:
     4426= MZULT
                      -3.095
                                 .851
                                       13.238 .663
                                                      -.96642 -3.49656
     4430: MAINACH
                      7.449
                               3.843
                                       3.758 .876
                                                      2.73675
                                                              .63115
     4448= MXNZ
                      -2.672
                               1.692
                                        2.494 .146
                                                      -2.12187 -.68509
     4450= CONSTANT
                               1.794
                                       26.813 .661
                      8.184
     1446:
     4476-
C
     0
     4510= VARIABLE(S) ENTERED ON STEP 4
     4576= TT
     4534:
     4546= MULTIPLE R
                                       DF SUM SQUARES MEAN SQ.
                     .7386 ANOVA
                      .5455 RECRESSION 4. 19.913 4.978
1.2288 RESIDUAL 11. 16.588 1.588
     4550= R SQUARE
                                                                 3.361
     4568= STD DEV
                    1.2286 RESIDUAL
                                                         1.568 SIC. .652
     4576= ADJ R SQUARE .3863 COEFF OF VARIABILITY 68.2PCT
     458#=
     4598: VARIABLE
                             S.E. B
                                         F SIG.
                                                       BETA ELASTICITY
     4686=
                                        3.928 .673 2.911AA
                     -3.512
                               1.977
     461# NZULT
                                       16.639 .668
                                                    2.91184 .67282
-2.36534 -.74433
-.18274 -.79255
      4620= HAXMACH
                                4.667
                       7.941
                              1.768
     4436= #112
                                       2.695 .129
                     -2.983
                                        .434 .523
     4646= TT
                                .023
                     -.015
     4656= CONSTANT 18.491
                               3,952
                                       7.648 .822
     4660=1INITIAL RECRESSION
                                               $1/14/82 15.84.$1. PAGE 12
     4476=
     4606: FILE - NOMANE (CREMTED - $1/14/82)
•
     4696=
     4700 - + + + + + + + + HULT : PLE REGRESSION + + + + + + + +
     471#=
     4728= DEP. VAR... TOOL
     4736=
     4746= VARIABLE(S) ENTERED ON STEP 5
                   NUMBER OF PROTOTYPE AIRCRAFT
     4756= PROTO
     4764=
                                        DF SUM SQUARES MEAN SQ.
     4776= MULTIPLE R .7518 AMOVA
                                                                   •
                      .5446 RECRESSION 5. 26.585 4.117 2.587
1.2416 RESIDUM. 18. 15.916 1.592 SIG. .894
     4796= R SQUARE
     4796: STD DEV
                    1.2616 RESIDUAL
     4966= ABJ R SQUARE .3459 COEFF OF VARIABILITY 76.8PCT
     4816=
     4820= VARIABLE
                       8
                             S.E. B
                                         F SIG.
                                                       BETA ELASTICITY
     4936=
     4846= NZULT
                               1.148
                                       18.454 .689
                                                     -1.15857 -4.18459
                     -3.716
     4954: MATHACH
                                                               .71669
                               4.172
                                        4.637 .572
                      8.381
                                                      3.67236
                                        2.966 .119
     4844: NYMZ
                     -3.174
                               1.864
                                                     -2.52994
                                                              -.81394
0
     4976= 11
                      -.519
                               . #25
                                        .572 .467
                                                      -.21977 -.95317
     4886- PROTO
                       .232
                                .357
                                         .422 .536
                                                       .15926
                                                               .25516
     4070- CONSTANT
                     18.783
                                        4.949 .825
                               4.005
     4990=11MITIAL REGRESSION
                                               81/14/82 15.84.81. PAGE 13
     4928= FILE - NOMARE (CREATED - 01/14/02)
0
     4936-
     4954:
     4968= BEP. VAR... TOOL
                              TOOLING
     4976=
     4900= VARIABLE(S) EXTERED ON STEP
     4990- TUTAREA TOTAL HETTED AREA
     5006=
     SOIG- MULTIPLE R .7693 AMOVA
                                       DF SUR SQUARES HEAR SQ.
0
     5020= R SQUARE
                      .5919 REGRESSION 4. 21.484 3.481
                                                                  2.175
    SPEED, STR. DEV
                     1 7844 BESTRUM 9 ..... 14 897 .... J.458 SIC 147
```

```
5848= ADU R SQUARE .3198 COEFF OF VARIABILITY 71.4PCT
     5658=
                                                            BETA ELASTICITY
     5646: VARIABLE
                         1
                                S.E. 3
                                            F
                                                  SIC.
     5678=
     SOCO- MZULT
                        -4.351
                                  1.427
                                            9.366
                                                  .#14
                                                          -1.3595#
                                                                    -4.96671
     SOPE: MAIRACH
                        7.122
                                  4.546
                                           2.454
                                                  .152
                                                           2.61896
                                                                     .60345
     5166= MENZ
                        -2.479
                                  2.897
                                            1.398
                                                  .267
                                                           -1.96896
                                                                     -.63572
                                            .953
     5118= TT
                                                  .354
                                                           -.93196
                                                                    -4.84287
                        -.679
                                   .861
                                                                      .33343
     5126= PROTO
                         .363
                                   .375
                                             .653 .446
                                                            .20016
                         .992
                                                  .453
     5136: TUTAREA
                                                             . 66687
                                                                     4.51229
                                  1.264
                                             .616
     5148: CONSTANT
                        9.254
                                  4.661
                                            4.642
                                                  .675
     5150-11MITTAL RECRESSION
                                                   $1/14/82 15.84.81. PAGE 14
     5144
     5179= FILE - NCHAME (CREATED - #1/14/82)
     5186=
     SIMP . . . . . . . . . . . ULTIPLE REGRESSION . . . . . . .
     5260=
     5218= DEP. VAR... TOOL
                                 TOOLING
     5226=
     5236= VARIABLE(S) ENTERED ON STEP 7
     5248: TOGUNAI MAXIMUM TAKEOFF GROSS HEIGHT
     5256=
     5268= MULTIPLE R
                        .9673 ANOVA
                                            DF SUM SQUARES MEAN SQ.
     5276= R SQUARE
                         .4517 REGRESSION
                                            7.
                                                    23.789
                                                               3.396
                                                                        2.139
     528#= STD DEV
                       1.2686 RESIDUAL
                                            8.
                                                     12.712
                                                               1.589 SIG. .154
     529#= ABJ R SQUARE .347# COEFF OF VARIABILITY
                                                     78.8PCT
     5366:
     5318= VARIABLE
                         8
                                S.E. 8
                                                  SIC.
                                                            BETA ELASTICITY
     5328=
     5336: MZULT
                        -3.955
                                            7.567 .825
                                                           -1.23584 -4.46878
                                  1.438
                        9.757
     5346= HAIRACH
                                                                      -82666
                                  4.989
                                            3.825
                                                  . #84
                                                           3.57665
     535## HINZ
                                                  .151
                        -3.592
                                  2.263
                                            2.519
                                                           -2.85294
                                                                     -.92112
     536#= TT
                        -.445
                                            1.967
                                                   .265
                                                           -5.27264 -22.86837
                                   .322
                                             .619 .894
     5376= PROTO
                         . #58
                                   .423
                                                            . #3981
                                                                      .66378
     5388= TUTAREA
                        5.115
                                  3.728
                                            1.883 .267
                                                           3.43938 23.27218
     5398= TOCHMAX
                        3.589
                                  3.861
                                            1.375
                                                  .275
                                                           2.26463 22.38187
     5466= CONSTANT
                       -31.150
                                             .864
     5416=
     5420=
     5436= ALL VARIABLES ARE IN THE EQUATION.
     5448=
     5454=
     5444=
     5470= COEFFICIENTS AND CONFIDENCE INTERVALS.
     5494:
     5496= VARIABLE
                                     95 PCT C.I.
     5500=
     5510= NZULT
                        -3.9554
                                   -7.2713
     5529= MAINACH
                         9.7571
                                            21.2618
                                   -1.7477
     5530= MINZ
                        -3.5924
                                              1.6272
                                   -8.8128
                                               .2988
     5546= TT
                         -.4449
                                   -1.1877
     55500 PROTO
                          . 6584
                                              1.6337
                                    -.9177
     SSLO= TUTAREA
                        5.1153
                                   -3.4818
                                            13.7123
     5570- TOCHMAX
                         3.5996
                                   -3.4689
                                             18.6469
                       -31.1562
                                   -.1E+63
                                             48.9747
0
     5480=
     5418: WARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED RECRESSION COEFFICIENTS.
0
     5428-
     5428·
     SAAGO NENZ
                        5.12339
     5450- TT
                         .24198
                                   .16377
     5446- PROTO
                         .12472
                                   .65495
                                            .17983
     5478- TOCUMAL
                       -2.16517
                                 -.15500
                                           -.64824
                                                    1.36762
     SLOG- TUTAREA
                                          -.42556
                       -2.26364 -1.19113
                                                    18.76261 13.89889
                                          ... 7487E
                      -11 17731 - - WYL
                                                    A 87484 ... 5.05427 . 24 00845
```

123

2 >

```
S766= NZULT
                     -.02254
                             - . 02828
                                      -.25663
                                                1.03206
                                                         .19576 -.43389
     5716:
     5728=
                     MINZ
                                      PROTO
                                               TOGUNAX TUTAREA MAXMACH
     5736=
     574#=
     5750= NZULT
                     2.66765
     5764=
     5776=
                    NZULT
     5794e
     5796=
     5000=1INITIAL RECRESSION
                                               61/14/82 15.64.61. PAGE 15
     5016=
     3025- FILE - NONAME (CREATED - 81/14/82)
     5836=
     5846= DEP. VAR... TOOL
                              TOOLING
     5874=
     5884z
     5898: SURMARY TABLE.
     5966=
     5916= STEP VARIABLE E/R
                              F MULT-R R-SQ CHANGE R OVERALL F SIG.
     5928=
     5930=
            1 NZULT
                             4.337 .486 .237 .237 -.486
                             4.395 .455 .429 .193 .674
     594#=
            2 MAINACH
                                                           4.892 .626
\mathbf{c}
     5956=
            3 MENZ
                             2.494 .726
                                        .528 .698 .669
                                                           4.447 .025
                              .434 .739
     5968=
                                         .546
                                                           3.301 .652
              TT
                                              .018 .253
     5974=
          5 PROTO
                              .422 .751 .564
                                              .018 .003
                                                           2.587 .094
     5996= 6 THTAREA E
5996= 7 TOCHNAX E
                               .616 .769 .592 .828 .168
                                                           2.175 .142
                              1.375 .867 .652
                                              .666 .336
                                                           2.139 .154
     6000=1INITIAL RECRESSION
                                               #1/14/82 15.#4.#1.
                                                                   PACE
     6816:
     6828: FILE - NONAME (CREATED - 81/14/82)
\mathbf{C}
     6848= + + + + + + + + + HULTIPLE REGRESSION + + + + + + + +
     6050=
     6666=
     6878= RESIDUAL PLOT.
     6896 z
     6896 s
                    Y EST. RESIDUAL -250
            Y VALUE
                                                     5.5
                                                                     +2SD
     4150=
     6116=
             6.837
                      5.151
     612#=
              -.362
                       -. $51
                               -.252
     6136=
              .763
                               -.209
                       .912
                                                    . I
     6144:
              .815
                       .448
                                .148
     4158=
                      2.674
              3.614
                                .941
0
     6160=
                      1.472
              1.411
                               -.241
     6170=
             2.672
                      1.736
                                .142
     6186=
              1.607
                      3.436
                              -1.827
     6196=
                       .592
                               1.213
              .285
                      1.117
                               -.832
               1.844
                       2.545
                                -.721
0
              1.699
                      1.776
                               -.342
              1.221
                      1.563
             2.607
                       .937
                               1.150
                      2.779
                              -1.607
     6248=
                                .332
             2.636
                      1.784
     6270-
     4200- MOTE - (+) INDICATES ESTIMATE CALCULATED MITH MEANS SUBSTITUTED
                R INDICATES POINT BUT OF RANCE OF PLOT
     1210-
0
     6316=
     6928- MUNDER OF CASES PLOTTED
     4330= MUNDER OF 2 S.D. OUTLIERS
                                       1 OR
                                                # PERCENT OF THE TOTAL
O
```

```
Selection of the selection of the
     1368=
     6378= NUMBER OF POSITIVE RESIBUALS
                                       7.
     6386= NUMBER OF NEGATIVE RESIDUALS
     4398= NUMBER OF RUNS OF SIGNS
                                       11.
     6486:
     6410= NORMAL APPROXIMATION TO SIGN DISTRIBUTION IMPOSSIBLE.
     6428= USE A TABLE FOR EXPECTED VALUES.
     6436=LINITIAL RECRESSION
                                               $1/14/82 15.$4.$1. PAGE 17
     Mar.
     6450= FILE - NOMAHE (CREATED - 01/14/82)
0
     6464=
     6496= SEP. VAR... HAVE
                              HANUFACTURING HOURS
     6516- REAN RESPONSE
                            3.76596
                                        STD. DEV.
                                                       .65468
     4526×
     6530= VARIABLE(S) ENTERED ON STEP 1
     6540: TOCHMAX MAXIMUM TAKEOFF CROSS WEIGHT
     4550:
                      .5842 ANOVA
                                        DF SUM SQUARES NEAM SQ.
     4548= MILTIPLE R
     6576= R SQUARE
                       .3413 RECRESSION
                                                        2.194
                                                                 7,253
                                       1.
                                                2.194
C
                                                           .383 SIG. .817
                       .5560 RESIDUAL
                                                 4.235
     4500= STO DEV
                                        14
     6590= ABJ R SQUARE .2942 COEFF OF VARIABILITY
                                                14.8PCT
     4466=
                                                       BETA ELASTICITY
     6416= VARIABLE
                       2
                             S.E. B
                                        F
                                             SIC.
     AA78z
     AARE TOCHNAY
                       . 229
                                .144
                                        7.253 .617
                                                       .59418 1.17776
     6646= CONSTANT
                      -.659
                               1.626
                                         .164 .692
     4456=
     LALE:
     4478:
     4494×
     4766= WARIABLE(S) ENTERED ON STEP 2
     6718= MZULT
                   ULTIMATE LOAD FACTOR
     4726=
                      .8957 AMOVA
     4736= MULTIPLE R
                                        DF SUM SQUARES HEAM SQ.
                                                       2.493 22.461
                                                4.984
     6740= R SQUARE
                       .7756 REGRESSION
                                        2.
                       .3332 RESIDUAL
     4750= STD DEV
                                        13.
                                                 1.443
                                                          .111 SIG. .000
     6768= ABJ R SQUARE .7410 COEFF OF VARIABILITY
                                                9. SPCT
     6778=
     6798: VARIABLE
                       8
                             S.E. B
                                        F
                                             SIC.
                                                      BETA ELASTICITY
     6796=
     LOSS= TOCUMAX
                                                      1.39261 2.86629
                       .924
                                . 132
                                       44.947 .566
     6918= NZULT
                      1.461
                                .279
                                      25.154 .000
                                                               .76989
                                                      1.64254
\boldsymbol{C}
     ARZO: CONSTANT
                     -9.548
                               2.826
                                       22.164 .905
     4938-1 INITIAL REGRESSION
                                               81/14/82 15.64.81. PAGE 18
     4844=
0
     4850= FILE - HOMANE (CREATED - $1/14/92)
     1818-
     GFF ............ REGRESSION .....
     690- SP. VAR... NAF
                              NAMES ACTURING HOURS
     (410- VARIABLE(S) ENTENES ON STEP 3
     LYZS- HXXZ
     6936=
     6940- INLTIPLE R
6950- R SOUME
0
                      .9324 AMOVA
.8492 RECRESSION
                                        OF SUR SOLINGES HEAR SQ.
                                                        1.963 26.614
.670 SIG. .600
                                                5.507
                                        3.
     6960- STO DEV .2644 RESIDUAL 12.
6970- ADJ R SOURCE .8367 COEFF OF WARIABILITY
0
                                                 7.1PCT
     40000
     4990= VARIABLE
                                         F
                                                       BETA ELACTICITY
                              L.E. 1
                                              512.
C
```

29

```
7626= KZULT
                       .977
                                 .265
                                        13.634 .003
                                                        .72724
                                                                 .53579
     7636: HINZ
                        .199
                                 .648
                                         8.413 .612
                                                                  . 62486
     7646= CONSTANT
                      -7.627
                                1.736
                                        19.297
                                               .001
     7050=
(
     7646=
     7476=
     C
     7494:
     7188- VARIABLE(S) ENTERED ON STEP 4
     7116= TT
     7129=
     7136= HALTIPLE R
                       .9428 ANOVA
                                         DF SUM SQUARES MEAN SQ.
     7146- R SQUARE
                       .8873 REGRESSION
                                                                 21.647
                                          4.
                                                  5.764
                                                           1.426
     7156- STB DEV
                       .2567 RESIDUAL
                                         11.
                                                   .725
                                                            .866 SIG. .688
     7166= ABJ R SQUARE .8463 COEFF OF VARIABILITY
                                                   6.9PCT
     7176=
C
     7188= VARIABLE
                              S.E. B
                        2
                                                        BETA ELASTICITY
                                          F
                                               SIC.
     7196=
     7266: TOCHRAY
                        . 984
                                        35.389
                                               . 566
                                                        1.48248 2.98865
     7210= NZULT
                       1.547
                                 .262
                                        15.948
                                                .662
                                                         .77867
                                                                 .57368
     7228= MXMZ
                       .159
                                 .872
                                         4.864
                                                .050
                                                         .36163
                                                                 .#1987
     7230= TT
                       -.869
                                  .867
                                         1.751
                                               .213
                                                        -.26635
                                                                 - . 23564
     7248= CONSTANT
                      -8.696
                                        21.675
                                               .561
                                                                     PAGE
     7256=1INITIAL REGRESSION
                                                61/14/82 15.64.61.
(
     7278= FILE - NONAME (CREATED - $1/14/82)
     7286=
     7296= + + + + + + + + + HULTIPLE REGRESSION + + + + + + +
C.
     7366:
     7318= BEP. VAR... HANF
                               MANUFACTURING HOURS
     7326=
C
     7338= VARIABLE(S) ENTERED ON STEP 5
     7346= PROTO
                    MUMBER OF PROTOTYPE AIRCRAFT
     7350=
C
     7360: MULTIPLE R
                       .9464 ANOVA
                                         DF SUM SQUARES MEAN SQ.
                       .8957 REGRESSION
                                                         1.152 17.168
     7378= R SQUARE
                                         5.
                                                  5.758
     7386- STD DEV
                       .2598 RESIDUAL
                                         14.
                                                   .471
                                                            .867 SIG. .868
     7396= ABJ R SQUARE .8435 COEFF OF VARIABILITY
                                                   7.SPCT
     7444:
     7418= VARIABLE
                        1
                              S.E. B
                                          F
                                               SIC.
                                                        BETA ELASTICITY
     7426=
     7436: TOCHHAI
                        .917
                                 .184
                                        24.773
                                               .561
                                                        1.37849
                                                                2.77902
     7446= NZULT
                        .931
                                 .294
                                         9,995
                                               .616
                                                        .69245
                                                                 .51616
C
     7456: MINZ
                        .156
                                 .874
                                         4.116
                                                         .28297
                                                                  .61864
                                               . 676
     7468= (T
                       -.660
                                                        -.22729
                                                                 - . 26169
                                 .667
                                         1.197
                                               .360
     7476= PROTO
                                 .000
                        .671
                                          .863 .391
                                                         .11673
                                                                 . #3815
C
     7486: CONSTANT
                      -7.949
                                2.661
                                        14.847
                                               . 663
     7496-11HITIAL REGRESSION
                                                81/14/82 15.64.81. PAGE 28
     7586
0
     7518= FILE - NOMANE (CREATED - 81/14/82)
     7536- + • • • • • • • • • • • ULTIPLE REGRESSION • • • • • • •
0
     7546-
2586- SEP. WAR... HANF
                               MANUFACTURING HOURS
     7544
0
     7576= WARIABLE(S) ENTERED ON STEP
     7500= THTAREA TOTAL WETTED AREA
     7519=
0
     7680- MULTIPLE R
                       .9481 AMBVA
                                                SOLIARES
     7416- R SQUARE
                       .0790 RECRESSION
                                          6.
                                                  5.706
                                                            .963
                                                                  13.349
                       .2484 RESIBUAL
     7429- STB BEV
                                                   .44
                                                            .072 SIG. .006
0
     7630- ABJ R SQUARE .8316 COEFF OF WARIABILITY
                                                   7.2PCT
     7648*
     7450- VARIABLE
                        8.5. 8
                                          F
                                               $16.
                                                        BETA ELASTICITY
C
     7446
     __1_02051 _ 3_48475
```

```
.306
.800
.844
     7406= NZULT
                                           9.456 .813
                                                            .69977
                                                                     .51555
     7496= MINZ
                         .163
                                            4.112 .673
                                                            .36784
                                                                     .02028
     7796= TT
                                            .445
                                                  .522
                                                          -1.19733
                                                                   -1.05928
                         -.842
     7718= PROTO
                         .654
                                             .367 .568
                                                            . 68789
                                                                     .#2872
     7729- TYTAREA
                         .410
                                   .753
                                             .296
                                                  . 666
                                                                      .96553
     7738= CONSTANT
                                           2.825 .127
                      -11.477
                                  4.829
     7740=LINITIAL RECRESSION
                                                   $1/14/82 15.84.$1. PAGE 21
     7754z
     7748= FILE - NONAME (CREATED - 61/14/82)
     7779=
\mathbf{C}
     MANUFACTURING HOURS
0
     7816-
     7828- VARIABLE(S) ENTERED ON STEP 7
     7836- MARNACH
                     MATIMUM MACH NUMBER
O
     7846=
     7850= MULTIPLE R
                                           DF SUN SQUARES NEAM SQ.
                         .9582 ANGVA
                                                               .829 16.623
     7868= R SQUARE
                         .9029 RECRESSION
                                            7.
                                                     5.865
     7870= STD DEV
                         .2794 RESIBUAL
                                            ۵.
                                                      .624
                                                                .678 SIG. .662
     7888: ABJ R SQUARE .8179 COEFF OF VARIABILITY
                                                      7.5PCT
     7894z
     7986: VARIABLE
                                                  SIC.
                                                            BETA ELASTICITY
                                S.E. 8
     7916=
                                           4.192 .675
                                                           2.46833
     7928= TOCHNAI
                        1.389
                                   .678
                                                                    4.21666
     7930= NZULT
                         ,936
                                   .319
                                           8.599 .919
                                                            .49165
                                                                     .50*57
                                             .055 .821
     7946= MXNZ
                        -,117
                                                           -,22169
                                                                    -.#146.
                                   .502
     7954= TT
                                             .451 .443
                                   .571
                        -.958
                                                          -1.62783 -1.43943
     7944 PROTO
                         .445
                                             .225 .648
                                                                     .52378
                                   .694
                                                            .67276
                         .559
     7976= TUTAREA
                                   .826
                                             .450 .518
                                                            .89582
                                                                   1.23642
     7986= MAXMACH
                          .626
                                  1.156
                                             .328 .587
                                                            .54637
                                                                     .82576
     7996= CONSTANT
                      -13.162
                                  7.781
                                           2.921 .126
     1666:
     0616=
     8826= ALL VARIABLES ARE IN THE EQUATION.
     6636±
     9848=
     1858=
     8868: COEFFICIENTS AND CONFIDENCE INTERVALS.
     8676=
     8000= VARIABLE
8090=
(
                                     95 PCT C.I.
     $166- TOCHMAX
                                    -,1753
                        1.3896
                                             2.9533
Ċ
     8110= NZULT
                         .9296
                                    .1947
                                             1.6646
     8128- MINZ
                         -.1172
                                   -1.2740
                                             1.6397
     8136= TT
                        -.6576
                                   - . 2223
                                              .1676
0
     8146- PROTO
                          .#45
                                   -.1718
                                              .2688
     8150: TUTAREA
                          .5592
                                             2.4646
                                   -1.3463
                          .4255
                                   -1.9244
                                             3.1755
     $168= MAXIMACH
0
     8176= CONSTANT
                      -13.1617
                                  -30.1267
                                             4.5973
     $136-
     8170-
     BESS- WARIANCE/COUNTIANCE MATRIX OF THE UNNORMALIZED RECRESSION COEFFICIENTS.
     1254-
     1220-
     OZ30- NXNZ
                         .25149
     8246° TT
                         .61107
                                   .00516
     8250- PROTO
                         .00623
                                            .88879
                                  .00290
     8248- TOCUMAL
                        -.14272
                                 -.84696
                                           -.#3145
                                                     .46018
     0270- TUTANEA
                        -.11117
                                 -.65651
                                           -.83673
                                                     .52871
                                                               .40278
     6286- MATHACH
                        -.54782
                                 -.02974
                                          -.61009
                                                      .33701
                                                               .29250
                                                                       1.22274
0
                                           -: 01231
                        -.00111
                                 -.00139
                                                                       -.02131
     8380-
8316-
                                          PROTO
                                                   TOCHMAI THTAREA MAXIMACH
                       MINZ
                                π
(
     1925-
```

```
9346: NZULT
                          .16157
      B35#=
                        MZULT
      8376=
C
      8396=
      8390-1INITIAL REGRESSION
                                                       61/14/82 15.64.61. PAGE 22
      1444:
      8418= FILE - NOMANE (CREATED - $1/14/82)
      1425=
      8430- • • • • • • • • NULTIPLE REGRESSION • • • • • • •
C
      8448=
                                    MANUFACTURING HOURS
0
      $476=
      8400- SUMMARY TABLE.
      M16:
      8500: STEP VARIABLE E/R
                                   F MULT-R R-SQ CHANGE R OVERALL F SIG.
      8518=
                                  7.253 .584
      8525=
             1 TOCHMAX
                                               .341 .341 .584
                                                                     7.253
      0536=
             2 NZULT
                                 25.156
                                         .881 .776
                                                     .434 -.836
                                                                    22.461
                                                                            .666
      8546=
                                  8.613 .932
                                               .869 .894 .456
                                                                    26.614 .666
      8556=
             4 TT
                           E
                                  1.751 .942 .897
                                                     .618 .332
                                                                    21.647
                                                                            .866
C
            5 PROTO E
4 TWTAREA E
7 MAXMACH E
      8564=
                                                                            .004
                                   .963 .946 .896
                                                     .668 .528
                                                                    17.168
                                    .296 .948 .899
      8576=
                                                      .663 .161
                                                                    13.349
                                                                            .444
      2596=
                                    .326 .956 .983
                                                     .864
                                                           .442
                                                                    19.623 .662
C
      8598=1INITIAL REGRESSION
                                                       81/14/82 15.64.61.
                                                                             PAGE 23
      9466=
      B618= FILE - NONAME (CREATED - $1/14/82)
      8426=
      8638= * * * * * * * * * * HULTIPLE REGRESSION * * * * * * * *
      8650=
      8660= RESIDUAL PLOT.
      8678=
              Y VALUE Y EST. RESIDUAL -2SD
                                                                                +2SD
      : MAAG
                                                              1.1
      1696=
      8744z
                3.239
                          3.656
                                      .189
      8716=
                2.526
                          2.675
                                     -.149
      1725=
                3.964
                          3.711
                                     . #93
      8738=
                3.246
                          3.311
                                     -.864
      8748=
                4.727
                                     .146
                          4.582
      $758±
                3.118
                          3.696
                                      .837
      8763=
                          4.161
                                     -.624
                4.678
O
      8776=
                3,738
                          4.645
                                     -.366
                                     .156
      8796=
                4.071
                          3.941
      8796=
8966=
                2.003
                          2.773
                                      . #3#
O
                4.412
                          4,222
                                      .196
      1916:
                4.297
                          4.143
                                     .155
      N28=
                                     -.448
                3.400
                          4.876
0
      1836=
                3.524
                                      .252
                          3.275
                          3.598
                                     -.242
                3,334
                4.745
                                      .834
                          4.718
0
      SUPP- MITE - (+) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
                    R INDICATES POINT OUT OF MANCE OF PLOT
0
      9916= IMMBER OF CASES PLOTTED
9926= IMMBER OF 2 S.B. OUTLIERS
0
                                                        # PERCENT OF THE TOTAL
     0746- VON HEIRMAN MATIO 2.15410
0750-
0766- MANUER OF POSITIVE RESIDUALS
0776- MANUER OF NEGATIVE RESIDUALS
0708- MANUER OF RANK OF SIGNS
                                                   PURBIN-WATSON TEST
                                                                       2.95798
0
                                              18.
                                              6.
                                              11.
      .PR96. .... ...
```

```
9860: NORMAL APPROXIMATION TO SIGN DISTRIBUTION IMPOSSIBLE.
     9818- USE A TABLE FOR EXPECTED VALUES.
     9020=1INITIAL RECRESSION
                                                $1/14/82 15.$4.$1. PAGE 24
     9834:
     1646= FILE - NOMANE (CREATED - $1/14/82)
     1650=
     9848: + + + + + + + + NULTIPLE REGRESSION + + + + + + + +
(
     9676:
     1005= BEP. VAR... MANUTAT
                               MANUFACTURING NATERIALS
C
                                                         .70284
     9186: NEAN RESPONSE
                             4.#2899
                                         STB. DEV.
     9116=
     .9128= VARIABLE(S) EXTERED ON STEP 1
     1130= PROTO
                    NUMBER OF PROTOTYPE AIRCRAFT
     1146=
     9150= MALTIPLE R
                       .5762 ANDVA
                                         DF SUM SQUARES HEAN SQ.
                                                         2.634
     9160= R SQUARE
                       .3554 RECRESSION
                                        1.
                                                                  7.729
                                                  2.634
     1170= STD DEV
                       .5841 RESIDUAL
                                                  4.777
                                                            .341 SIG. .#15
                                         14.
     9186= AUJ R SQUARE .3894 COEFF OF VARIABILITY
                                                 14.SPCT
     11962
     9200: VARIABLE
                                          F SIG.
                        В
                              S.E. B
                                                        BETA ELASTICITY
     921#=
     9226= PROTO
                        .392
                                 .141
                                        7.726 .815
                                                         .59617 .19241
     9230= CONSTANT
                       3.254
                                 .315 166.754 .666
     9244=
     9256=
     9266=
     9286=
     9298= VARIABLE(S) ENTERED ON STEP 2
     9300= TOGHNAX MAILHUM TAKEOFF CROSS WEIGHT
     9316=
     9328= MULTIPLE R
                       .7938 MOVA
                                         DF SUM SQUARES MEAN SQ.
                                                        2.335 11.874
                                       2.
13.
     9336= R SQUARE
                       .6361 REGRESSION
                                                  4.676
     9340= STD DEV
                       .4592 RESIDUAL
                                                  2.741
                                                           .211 SIG. .882
     9350: ADJ R SQUARE .5732 COEFF OF VARIABILITY
                                                 11.4PCT
     9366=
     9376= VARIABLE
                                               SIC.
                                                        BETA ELASTICITY
     938#=
     9398= PROTO
                        .391
                                 .111
                                        12.472 .864
                                                         .59568
     9466= TOCHMAX
                        .374
                                         9.656 .568
                                                        .52414 1.84345
     9418= CONSTANT
                       -.956
                                1.375
                                          .477
     9428=11HITIAL REGRESSION
                                                81/14/82 15.84.81. PAGE 25
     9438=
     944#= FILE - NOMANE (CREATED - #1/14/82)
     945#=
     9468= • • • • • • • • NULTIPLE REGRESSION • • • • • • •
     9478=
     1486= BEP. VAR... HANNAT
                               MANUFACTURING MATERIALS
C
     1496=
     9500- WARLABLE (S) ENTERED ON STEP 3
     1516- MALT
                    ULTIMATE LOAD FACTOR
0
     1526
     1536- MILTIPLE R
1546- R SOURCE
                                         OF SUR SQUARES HEAM SQ.
                       .9297 ANDVA
                                                        2.135 25.479
                        MOTERATION CANE.
                                         3.
                                                  6.465
O
     9556- STB DEV
                        .2095 RESIDUAL
                                         12.
                                                  1.965
                                                             .994 SIG. .506
     9568: ABJ A SOURCE . 8384 COEFF OF VARIABILITY
                                                  7,2PC1
     9576a
O
     9506= VARIABLE
9596=
9606= PROTO
                              S.E. 3
                                               116.
                                                        BETA ELASTICITY
                        .176
                                         4.344
                                                                  .69454
                                 .84
                                               . 659
                                                         .24813
0
     NIA- TOCHNI
                                 .134
                                        42.639
                      .864
1.334
                                               .866
                                                        1.24675 2.47669
                                               .001
                                 .293
     9428= HZIE.T
                                        20,710
                                                         ,92442
                                                                 .67255
     9436: CONSTANT
                                        25.043 .661
                      -0.761
                                1.766
(
     96440
     1446
```

```
9454=
     1678= * * * * * * * * * * * * * * * * * *
      1404=
      9698= VARIABLE(S) ENTERED ON STEP 4
C
     1786= HINZ
      9716=
                         .9551 ANOVA
.9123 RECRESSION
     1728= MALTIPLE R
                                            DF SUM SQUARES MEAN SQ.
C
                                                                     28.684
     1736= R SQUARE
                                            4.
                                                     6.765
                                                             1.699
     9740= STB DEV .2431 RESIDUAL 11.
9750= ADJ R SQUARE .8884 COEFF OF VARIABILITY
                                                       .456
                                                                 .859 SIC. .666
                                                       4.SPCT
0
     9764z
     9770- WARIABLE
                          •
                                 S.E. B
                                             F
                                                   SIC.
                                                             BETA ELASTICITY
     1785-
     1796= PROTO
                          .131
                                    .673
                                            3.226 .166
                                                             .19998
                                                                       .86454
      9988- TOCUMAX
                                           52.677 .888
                                                            1.17453
                          .839
                                   .116
                                                                     2.33825
      1016- NZULT
                         1.685
                                    .264
                                                    .602
                                                                       .54768
                                           16.611
                                                             .75196
0
      9820= MINZ
                         .158
                                    .664
                                            6.617 .632
                                                                       .61869
                                                             .27816
      9836= CONSTANT
                                  1.766
                        -7.929
                                           21.666
                                                   .661
      9848=11NITIAL RECRESSION
                                                    81/14/82 15.64.81. PAGE 26
      9854=
     9866: FILE - NOMANE (CREATED - 81/14/82)
     0074z
      7886 - + + + + + + + + HULTIPLE RECRESSION - + + + + + + +
      9896=
     9960= BEP. VAR... MANNAT
                                 MANUFACTURING MATERIALS
C
      9926: VARIABLE(S) ENTERED ON STEP 5
     993#= TT
C
     1946=
     9958= MULTIPLE R
                         .9574 AMOVA
                                            DF SUM SQUARES MEAN SQ.
     9960= R SQUARE
                         .9167 RECRESSION
                                                             1.359 22.664
                                            5.
                                                  6.793
     9978= STE DEV
                         .2485 RESIDUAL
                                            18.
                                                      .617
                                                                .662 SIC. .666
       9988- ABJ R SQUARE .8758 COEFF OF VARIABILITY
                                                       6.2PCT
     1196=
\mathbf{C}
     SOOG: VARIABLE
                                S.E. B
                                            F
                                                  SIC.
                                                            BETA ELASTICITY
     1616=
     6626= PROTO
                          .126
                                            2.451 .149
                                   .576
                                                             .18225
                                                                       . 05882
     6636: TOCUMAZ
                          .934
                                   .177
                                           27.938
                                                   .886
                                                            1.36614
                                                                     2.66424
     0040: NZULT
                        1.140
                                    .282
                                           14.289
                                                   . 882
                                                            .78993
                                                                      .57471
                         .139
     MESE: NYM?
                                    .671
                                            3.851 .678
                                                            .24475
                                                                     .#1592
     BOLE TT
                         -.665
                                    .867
                                             .527 .485
                                                            -.13475
                                                                     -.11773
     9676: CONSTANT
                        4.44
                                  1.978
                                           18.934 .661
     9000-LINITIAL RECRESSION
                                                    $1/14/82 15.84.81. PAGE 27
\mathbf{C}
     8188= FILE - NOMANE (CREATED - 61/14/82)
     6116=
     4134s
     6146- BEP. WAR... MANNAT
                                 HAMUFACTURING HATERIALS
     6156e
     0146- WATABLE (S) ENTERED ON STEP 4
0170- TUTAREA TOTAL VETTED AREA
0
     SING- MUTIPLE R
                         .9636 AMOVA
.9285 RECRESSION
                                                SUM SQUARES HEAN SQ.
                                                     4.80
                                            6.
1.
                                                                       19.467
                                                              1.147
                                                       .326
     FZ10- STD DEV
                         .2427 NESIDIAL
                                                                 .659 SIC. .806
     8228- ABJ R SOUME
                        . SOOS COEFF OF WARIABILITY
                                                      4.SPCT
     8228a
0
     6246- WARTABLE
                         ı
                                 S.E. 3
                                            F
                                                   SIC.
                                                            META ELASTICITY
     6256a
     6266- PROTO
                                            1.097
                                                   .222
                                                             .12795
                                                                       .64129
     0279= TOCUMAX
                         1.537
                                    .524
                                            8.557
                                                   .617
                                                           2.15545
                                                                     4.29107
     OZOG- NZULT
                         1.14
                                   .276
                                           17.613
                                                  .002
.640
.227
                                                            .96376
                                                                      .58473
     9290= RINZ
9200= TT
                         .145
                                   .672
                                            5.210
                                                             .29142
                                                                       -61897
                                            1.404
                         -.075
                                    .657
                                                           -1.96121 -1.71340
     ATTURA THE AREA
                                                    754
```

```
.631
        6320 - CONSTANT
                         -15.739
                                      6.178
                                                6.567
        8336-11NITIAL RECRESSION
                                                        81/14/82 15.84.81. PAGE 28
        8346=
        8356= FILE - NOMANE (CREATED - $1/14/92)
        8376= + +
                 *******************
       6396= DEP. VAR... NAMMAT
                                     MANUFACTURING MATERIALS
       6418= VARIABLE(S) ENTERED ON STEP 7
       8428= MAINACH
                       MAXIMUM MACH MUMBER
       8436e
       9446- MOLTIPLE R
9456- R SQUARE
                                                DF SUN SQUARES MEAN SQ.
                            .9675 ANOVA
                            .9366 RECRESSION
                                                7.
                                                         6.936
                                                                     .991
                                                                            16.717
       84.6- STB DEV .2435 RESIDUAL 8.
8476- MBJ R SQUARE .8866 COEFF OF VARIABILITY
                                                           .474
                                                                     .659 SIC. .666
                                                           6.SPCT
       8498= VARIABLE
                                   S.E. B
                                                F
                                                      SIC.
                                                                 BETA ELASTICITY
       #544=
       #51#= PROTO
                            .676
                                       . #82
                                                 .737
                                                      .415
                                                                 .18685
                                                                           .83449
       8528= TOCHMAI
                           1.798
                                       .591
                                               9.249
                                                      .416
                                                                2.51766
                                                                         5.61216
       8538= MZULT
                           1.143
                                       .278
                                               16.952
                                                      .663
                                                                .79239
                                                                           .5765#
       8548= MINZ
                           -.253
                                       .437
                                                .336
                                                      .578
                                                                -.44659
                                                                          -.02904
       8556= TT
                           -.897
                                       .562
                                               2.447 .156
                                                               -2.56622
                                                                         -2.23677
       6546= THTAREA
                           1.652
                                      .729
                                               2.134 .182
                                                                1.56951
                                                                         2.13918
       8576= MAIMACH
                            .934
                                       .964
                                                .944 .366
                                                                 .76146
                                                                           .83546
       $588= CONSTANT
                         -18.259
                                     6.711
                                               7.483 .826
       8598±
       4444:
       8618= ALL VARIABLES ARE IN THE EQUATION.
       8628=
(
      8638=
       1648:
       9450= COEFFICIENTS AND CONFIDENCE INTERVALS.
C
      6678= VARIABLE
                                        95 PCT C.I.
      6696= PROTO
                            . 6782
                                       -.1183
                                                  .2586
      6766= TOCHMAX
                          1.7978
                                        .4346
                                                 3.1689
      8718= NZULT
                          1-1434
                                                 1.7839
                                        .5836
      8728= MINZ
                          -.2534
                                      -1.2615
                                                  .7547
      4734= TT
                          -.0973
                                       -.2448
                                                  .8441
                                      -.6696
-1.2858
      9740= THTAREA
                          1.6518
                                                2.7122
      8758= MAIMACH
                           .9362
                                                3.1582
      8768= CONSTANT
                        -18.2595
                                     -33.7346
                                               -2.7844
      $778=
€.
      8798: VARIANCE/COVARIANCE MATRIX OF THE UNMORMALIZED RECRESSION COEFFICIENTS.
      1966 =
O
      1818=
      9026= H3HZ
9030= TT
                          .19111
                           .0993
                                    .00397
     POSO- TECHNAL
                                             .05448
.02388
                           .66473
                                    .00212
                         -.16637
                                   -.03566
                                                        .24943
      ADLO- TRITAGE
                                   -.54443
                         -.00442
                                             -.62333
                                                         .46147
.25456
                                                                   .51945
      9079- MAIRACH
9006- MZULT
0
                         -.41537
                                   -.02230
                                             -.81374
                                                                   .22211
                                                                            .92844
                                   -.00105
                                             -.80935
                                                         .03654
                                                                            -.61419
0
                        MINZ
                                  π
                                            PROTO
                                                      TOGUMAY TYTAREA
                                                                          MAXMACH
      P18-
O
      POP- HZULT
                          .67713
      m
      1750-
                        MELT
      -
      8974e
```

```
6986=IINITIAL RECRESSION
                                                 61/14/82 15.64.61. PAGE 29
     1886= FILE - NONAME (CREATED - 81/14/82)
     1616=
     1828= + + + + + + + + HULTIPLE REGRESSION + + + + + + +
     1836=
     1646= DEP. VAR... MANHAT
                               HANUFACTURING MATERIALS
C
     1656=
     1646-
     1676= SUMMARY TABLE.
     1898= STEP VARIABLE E/R
                             F MULT-R R-SQ CHANGE R OVERALL F SIG.
     1186-
                              7.728 .596 .355 .355 .596
9.656 .794 .638 .275 .525
     1116=
            1 PROTO
                                                              7.725
                                                                    .615
            2 TOCHMAN E
     1126=
                                                             11.674 .662
                             28.718 .936 .864 .234 .858
     1136=
           3 NZULT
                                                             25.479
                                                                    . 666
                        Ε
                                                             28.684
                                                                    .666
     1148=
           4 MXN7
                               6.617 .955 .912 .648 .479
                        Ε
                                .527 .957 .917
                                                .664 .367
                                                             22.664
     1156= 5 11
                                                                     .466
     1168= 6 THTAREA E
                               1.482 .964 .928 .812 .119
                                                             19.467 .866
     1176= 7 MAXMACH E
                               .944 .967 .936 .668 .435
                                                            16.717 .666
     1180=1INITIAL REGRESSION
                                                 61/14/82 15.64.61.
                                                                     PACE 36
     1286= FILE - NONAME (CREATED - 81/14/82)
     121#=
     123#=
     1246=
     1250= RESIDUAL PLOT.
     1268=
     1270=
            T VALUE T EST. RESIDUAL -25D
                                                        1.5
                                                                        +2SD
     1296=
     129#=
              3.438
                       3.249
                                  .189
     1366=
              2.786
                       2.822
                                 -.636
     1316=
              3.968
                                 -.172
                        4.686
•
              3.873
                       3.844
     1326=
                                 .#29
     1336=
              5.656
                       4.853
                                  .197
     1346=
              3.288
                       3.252
                                  . #36
     1354=
                                  .035
              4.385
                       4.349
              3.918
     1366=
                       4.336
                                 -.428
     1378=
              4.251
                       4.301
                                 -.149
     1396=
              3.666
                       2.994
                                  .$14
     1398:
              4.801
                       4.637
                                 .163
     1466=
              4.662
                       4.538
                                 .125
(
     1416=
              4.268
                                 -.283
                        4.471
     1428=
              3.857
                                 .267
                       3.649
     1436=
              3.731
                       3.952
                                 -.222
0
     1446=
              5.246
                       5,142 .164
     1450=
     1446- NOTE - (+) INDICATES ESTIMATE CALCULATED WITH HEAMS SUBSTITUTED
0
     1476=
                 R INDICATES POINT OUT OF RANGE OF PLOT
     1400-
1410-
     1500- HANGER OF CASES PLOTTED
     1910- MANDER OF 2 S.B. OUTLIERS
                                         4 00
                                                6 PERCENT OF THE TOTAL
     1525-
     1530- VOII NEUMAIN RATTO 2.47845
                                             BURBIN-MATSON TEST 2.32355
     1544=
     1956- HONDER OF POSITIVE RESIDUALS
1948- HONDER OF NEGATIVE RESIDUALS
1978- HONDER OF NUMB OF SIGNS
     1598- HORNAL APPROXIMATION TO SIGH BISTRIBUTION IMPOSSIBLE.
     1688- USE A TABLE FOR EXPECTED VALUES.
     1610-LINITIAL RECRESSION
                                                 81/14/82 15.94.81. PAGE 31
C
     1629=
 14342 FUE - MINNE LITERATED - AJ (14792)
```

```
The HE IS STREET, SALES AND THE
      1644×
      1658 * * * * * * * * * * NULTIPLE RECRESSION * * * * * * *
      1644=
      1676= DEP. VAR... ENG
                              ENGINEERING HOURS
      1686=
      1698= HEAN RESPONSE
                            1.96596
                                       STD. DEV.
                                                     .78148
      1766=
      1718: VARIABLE(S) ENTERED ON STEP 1
      1726= PROTO
                   NUMBER OF PROTOTYPE AIRCRAFT
      1736=
      1746= MULTIPLE R .5767 ANOVA
                                                     MEAN SQ. F
2.984 6.763
                                       DF SUN SQUARES MEAN SQ.
      1750= R SQUARE
                      .3257 REGRESSION 1. 2.984
.6442 RESIDUAL 14. 6.177
      1740- STB DEV
                                                        .441 SIG. .821
     1778= ABJ R SQUARE .2776 COEFF OF VARIABILITY 34.9PCT
      1724s
     1796= VARIABLE
                             S.E. B
                                       F
                                           SIG.
                                                     BETA ELASTICITY
     1860=
      1916= PROTO
                       .417
                                       6.763 .821
                               .160
                                                     .57672 .43293
      1826= CONSTANT
                      1.481
                               . 358
                                      9.158 .559
      1936=
      1854=
     1870=
     1886= VARIABLE(S) ENTERED ON STEP 2
     1898= TOCHMAK MAXIMUM TAKEOFF CROSS WEIGHT
     1966=
     1918: MULTIPLE R
                      .8026 ANOVA
                                      DF SUM SQUARES MEAN SQ.
                                      2.
                                                     2.946 11.715
     1920= R SQUARE
                      .6432 RECRESSION
                                               5.892
                                     13.
     1936= STD DEV
                      .5015 RESIDUAL
                                               3.269
                                                        .251 SIG. .##1
     1948: ABJ R SQUARE .5883 COEFF OF VARIABILITY 26.3PCT
     1950=
     1968= VARIABLE
                      B S.E. B
                                       F SIC.
                                                     BETA ELASTICITY
     1976=
                      .416
     1986= PROTO
                               .121
                                                     .57619
                                    11.844 .664
     1996= TOCHMAI
                      .447
                               .132
                                     11.565 .665
                                                     .54342 2.63634
     2666= CONSTANT
                   -3.943
                              1.582
                                      6.893 .821
     2616=1INITIAL REGRESSION
                                             81/14/82 15.84.81. PACE 32
     2626=
     2836= FILE - NOMARE (CREATED - $1/14/82)
     2846:
     2838 - - - - - - - - HULTIPLE REGRESSION - - - - -
     2068=
     2070= BEP. VAR... ENG
                             ENGINEERING HOURS
     2896= VARIABLE(S) ENTERED ON STEP 3
    2100= NZULT
                  ULTIMATE LOAD FACTOR
     2114s
     2125- MULTIPLE R
                     .9256 MIOVA
                                      OF SUN SQUARES HEAD SQ.
    2130= R SQUARE
                     .8475 RECRESSION
                                      3. 7.764 2.589 22.234
     2146- STD DEV
                      .3412 RESIDUAL
                                      12.
                                              1.397
                                                       -116 SIG. .666
     2156- ABJ R SQUARE .8094 COEFF OF WARIABILITY
                                             17.99CT
    2145-
     2176- WRIABLE
                      1
                            S.E. 1
                                       F
                                            SIC.
                                                    SETA ELASTICITY
    2100-
O
    2196- PROTO
                      .173
                               .099
                                      3.767 .676
                                                     .24419
                                                             .26641
     2200- TOCHMAX
                      .979
                              .140
                                    37.466 .000
                                                    1.23290
                                                           5.76888
     2216 HZILT
                     1.394
                               . 345
                                     14.905 .002
                                                     .86366
                                                           1.47476
0
    2228= CONSTANT -12.284
                              2.318
                                     29.102 .000
    2236=
    2246-
0
    2250=
     2274=
    2200- VARIABLE(S) ENTERED ON STEP 4
    7796s TT
```

```
2366=
     2316= MULTIPLE R
                       .9252 MOVA
                                          DF SUM SQUARES MEAN SQ.
                       .8559 REGRESSION 4. 7.841
.3464 RESIDUAL 11. 1.328
                                                          1.966 16.336
     2320= R SQUARE
     2336= STD DEV
                                                             .126 SIC. .666
     2346= ABJ R SQUARE .8635 COEFF OF VARIABILITY 18.2PCT
     2356=
     2368= VARIABLE
                               S.E. B
                                           F
                                                SIC.
                                                          BETA ELASTICITY
     2376=
                                          4.248 .664
     2396= PROTO
                        .217
                                                          ,29749
                                                                    .22567
                                  .165
     2398= TOCHHAI
                                         13.912 .863
                                                         1.67147 5.61359
                        .851
                                  .228
     2460= NZULT
                                 .354
                                         14.578 .663
                                                          .84143 1.43866
                       1.356
                                  . 689
                                                                   .35545
     2416= TT
                         .667
                                           .645 .441
                                                          .17316
     2428= CONSTANT -11.499
                                 2.55#
                                         28.337 .681
     2436=1INITIAL RECRESSION
                                                 #1/14/82 15.#4.#1. PAGE 33
     2448=
     2456= FILE - MONAME (CREATED - 01/14/82)
O
     2468=
     2476= + + + + + + + + + NULTIPLE REGRESSION + + + + + + + + +
     2486=
(
     2490= DEP. VAR... ENG
                                ENCINEERING HOURS
     7544=
     2516= VARIABLE(S) ENTERED ON STEP 5
     2529= THTAREA TOTAL HETTED AREA
     2536=
     2548= MULTIPLE R
                      .9419 ANOVA
                                          DF SUM SQUARES MEAN SQ.
     2558= R SQUARE
                       .8872 REGRESSION
                                          5. 8.128
                                                          1.626
                                                                   15.736
                                       15.
     2560= STD DEV
                       .3214 RESIDUAL
                                                             .103 SIC. .000
                                                   1.633
     2576= ADJ R SQUARE .8369 COEFF OF VARIABILITY 16.9PCT
     7586=
     2596= VARIABLE
                               S.E. B
                                           F SIG.
                                                          BETA ELASTICITY
                        8
     2684=
     2616= PROTO
                                                          .37177
                        .271
                                          6.938 .625
                                  .163
                                                                   . 28281
     Z629= TQCUMAI
                       -.239
                                  .687
                                           .121 .735
                                                         -.36663 -1.46672
     2630= NZULT
                       1.235
                                  .335
                                         13.569 .864
                                                          .76971 1.31622
     2648= TT
                         .129
                                  .674
                                          3.686 .116
                                                         3.45294 6.26895
     2650= THTAREA
                       -1.431
                                  .859
                                          2.777 .127
                                                        -1.92867 -6.15289
     266#= CONSTANT
                       1.326
                                 8.548
                                           .827 .873
     2678=1INITIAL RECRESSION
                                                 01/14/82 15.84.61. PAGE 34
     2686=
     2698= FILE - NOMANE (CREATED - 81/14/82)
     2766=
     2718- * * * * * * * * * * * NULTIPLE REGRESSION * * * * * * *
     2728=
(
     2736: DEP. VAR... ENG
                                ENGINEERING HOURS
     2758= VARIABLE(S) ENTERED ON STEP 6
0
     2746= MXMZ
     2776±
                        .1433 AMOVA
     2706= MULTIPLE R
                                          DF SUM SQUARES MEAN SQ.
0
                                                   8.151 1.358 12.168
                                         6.
                        .8098 RECRESSION
     2796= R SQUARE
     2000- STB DEV .3356 RESIDUAL 9.
2010- ABJ R SQUARE .8163 COEFF OF WARIABILITY
                                                    1.610
                                                              .112 SIG. .861
                                                 17.APCT
0
     2825=
     2000- WRIABLE
                                                 SIC.
                                                          BETA ELASTICITY
                               S.E. 3
0
     2858- PROTO
                         .259
                                          5.483 .644
                                                          .35563
                                  .111
                                                                    .26932
     2846- TOCHMAI
                        -.184
                                  .724
                                           .544 .964
                                                         -.23139 -1.88271
     2870- NZULT
                                          9.334 .814
                       1.145
                                  .361
                                                          .72434 1.24265
     2006= TT
2006= TUTANEA
                         .125
                                          2.282 .145
                                                        2.83359 5.81854
                                  .479
                                                        -1.74794 -5.59954
                       -1.362
                                  .131
                                          1.924 .199
                                           .257 .648
     2906- MXMZ
                         .84
                                  .186
                                                          .57216
                                                                  .01163
     2918- CONSTANT
                         .450
                                 8.515
                                            .664
                                                .941
     2928-IINITIAL REGRESSION
                                                 81/14/82 15.84.81. PAGE 35
     2930=
     2948* FILE - NOMANE (CREATED - 61/14/82)
     .2954# ....
```

```
2966= + + + + + + + + HULTIPLE RECRESSION + + + + + + + + +
     2976=
     2988: DEP. VAR... ENG
                                 ENGINEERING HOURS
     2996=
C
     3000= VARIABLE(S) ENTERED ON STEP 7
     3016= NATHACH MAXIMUM MACH MURBER
     3029=
     3836= MULTIPLE R
                                            DF SUM SQUARES MEAN SQ.
                         .9451 ANOVA
                         .8931 RECRESSION
                                                     8.182
                                                                        9.551
     3646: R SQUARE
                                            7.
                                                               1.169
     3856= STD DEV
                        .3498 RESIDUAL
                                                                .122 SIG. .802
                                                       -979
                                             8.
     3666= ADJ R SQUARE .. 7996 COEFF OF VARIABILITY
                                                    18.4PCT
     3676=
     366= VARIABLE
                                                            BETA ELASTICITY
                         3
                                S.E. B
                                             F
                                                  SIG.
     3166= PR0T0
                          .275
                                    .117
                                            5.269 .651
                                                             .369:1
     3116= TOCHMAI
                         -.376
                                   .849
                                                            -.47315
                                             .196 .678
                                                                    -2.21394
     3126= MZULT
                        1.177
                                   .399
                                            6.767 .018
                                                                    1.25476
                                                            .73389
     3136= TT
                                    . 889
                          .137
                                            2.337 .:65
                                                           3.23341
                                                                     6.63953
     3146= THTAREA
                        -1.469
                                  1.#35
                                                                    -6.31414
                                            2.815 .194
                                                           -1.97181
                         .356
                                                             .56489
     3158= HYRZ
                                   .628
                                             .322 .586
                                                                      .68635
                                  1.384
                                             .252 .629
                                                           -.56838
     3166: MAINACH
                        -.695
                                                                     -. #5563
     317#= CONSTANT
                        2.521
                                  9.642
                                             .648 .806
     3186=
     319#=
     3266= ALL VARIABLES ARE IN THE EQUATION.
(
     3216=
     3226=
     3236:
     3246= COEFFICIENTS AND CONFIDENCE INTERVALS.
     3756=
     3266= VARIABLE
                         1
                                     95 PCT C.I.
C
     3276=
     3296= PROTO
                         .2695
                                    -.6613
                                               .5463
                                  -2.3343
     3296= TOCHMAX
                        -.3756
                                             1.5836
     3366= NZULT
                        1.1775
                                    .2573
                                             2.8976
     3318= TT
                         .1367
                                    -.6695
                                               .3428
     3328- THTAREA
                        -1.4685
                                   -3.8543
                                               .9172
     333#= MXMZ
                         .3563
                                             1.8848
                                   -1.6921
     3346: MAINACH
                         -.6948
                                   -3,8874
                                             2.4979
     3350= CONSTANT
                        2.5213
                                  -19.7146
                                            24.7565
     3366=
     3376:
     3388= VARIANCE/COVARIANCE HATRIX OF THE UNMORNALIZED RECRESSION COEFFICIENTS.
(
     339#=
     3466=
     3416= HXNZ
                        .39456
     3426= TT
                         .81863
                                  .55799
     3436= PROTO
                         .88976
                                   .00439
                                            .51379
                        -.22373
     3448: TOCHMAY
                                 -.07361
                                           ~.64931
                                                      .72141
O
     3450= THTAREA
                        -.17428
                                 -.09173
                                           -.64817
                                                      .82883
                                                              1.07836
      3466= MAZMACH
                        -.85754
                                 -.54662
                                           -.02836
                                                      .52956
                                                               . 45854
                                                                       1.91683
      3476- HZULT
                        -.60174
                                 -.66218
                                           -. #193#
                                                      .67948
                                                               .61567
                                                                        -. #3341
0
     24%=
3586=
                       MINZ
                                π
                                          PROTO
                                                    TOCHNAY THTAREA
                                                                      MAXMACH
0
     2516=
                         .15923
     3528= NZULT
      3536=
0
     3544=
                       HZULT
      3550-
      3544
(
     3576=1INITIAL RECRESSION
                                                   81/14/82 15.84.81. PACE 36
     3506s
      3590= FILE - NOMAME (CREATED - 01/14/02)
      Million of alexanded Tipir Breeks Congress as a sas
```

```
:0.1:
     3630: DEP. VAR... ENG
                                ENGINEERING HOURS
     3444z
     3456=
     3668: SUMMARY TABLE.
     3676=
     3600: STEP VARIABLE E/R
                                F MULT-R R-SQ CHANGE R OVERALL F SIG.
(
     3499=
     3796=
            1 PROTO
                               6.763 .571
                                                 . 326
                                                       .571
                                                               6.763
                                            .326
                                                                      .621
            2 TOCHMAI
                               11.565
                                            .643
                                                 .317
                                                       .564
                                                               11.715
                                                                      .561
     3716=
                         Ε
                                      . 862
                               16.485
                                     .921
                                            .848
            3 NZULT
                                                 .284
                                                       . 582
                                                               22.234
                                                                      .966
     3728=
                                                                      .666
     3736:
                                 .646
                                      . 925
                                            .856
                                                 .666
                                                       . 465
                                                               16.336
               TT
                                                                      . ###
                               2,777
                                            .887
                                                      . 366
     3744:
            5 THTAREA
                                                 .631
                        £
                                     .942
                                                              15.736
                                                                      .661
            & MINZ
                                                              12.166
     3756×
                         Ε
                                 .207 .943 .896
                                                 .663 .323
     3744=
           7 MAIMACH E
                                 .252 .945 .893
                                                 .663
                                                       .288
                                                               9.551 .862
     3776=11MITIAL REGRESSION
                                                  $1/14/82 15.64.61.
                                                                        PAGE 37
     378#=
     3796= FILE - NONAME (CREATED - $1/14/82)
     361g= + + + + + + + + + HULTIPLE REGRESSION + + + + + + +
     3826=
     3834=
(
     384#= RESIDUAL PLOT.
     3854=
                     Y EST. RESIDUAL -25D
                                                                          +250
      3844=
            T VALUE
                                                         6.
C
     387#=
      388#=
     3896:
               .698
                         .756
                                  -.858
C
     3966=
               1.647
                        1.889
                                  -.242
     39:5=
               1.716
                        1.768
                                  -. #52
     392#=
               3.466
                        3.454
                                   .612
C
               1.459
                        1.255
     3936=
                                   .203
     1944:
               1.881
                        1.995
                                 -.114
     3958=
               2.245
                        2.317
                                 -. 672
C
     396#=
               2.135
                        2.122
                                   .#13
     3978=
               1.664
                         .846
                                  .165
     3984=
               2.754
                        2.256
                                   .497
               1.813
                        2.331
                                  -.518
               1.953
                        2.267
                                  -.314
     4616=
               2.228
                        1.984
                                  . 236
               1.917
                        1.977
     4474=
                                  -.666
     4434z
               3.645
                        2.661
                                   .384
      ISIS:
      4656= NOTE - (+) INBICATES ESTINATE CALCULATED WITH MEANS SUBSTITUTED
                  R INDICATES POINT OUT OF RANGE OF PLOT
      4848=
      4676=
O
      4896= NUMBER OF CASES PLOTTED
                                        16.
     4186= NUMBER OF 2 S.D. OUTLIERS
                                          6 OR
                                                   & PERCENT OF THE TOTAL
0
     4114
      4128- 988 NEUMANN RATIO 2.19396
                                               DURBIN-MATSON TEST 2.05684
     4130-
     4146- MINNER OF POSITIVE RESIDUALS
      4130- MINDER OF NEGATIVE RESIDUALS
      4148- MINNER OF RUNS OF SIGNS
0
      4186- MORMAL APPROXIMATION TO SICH BISTRIBUTION IMPOSSIBLE.
      4198= USE A TABLE FOR EXPECTED VALUES.
0
      4200-11HITIAL RECRESSION
                                                  61/14/82 15.64.61.
                                                                       PAGE 38
      4216:
      4225:
0
      4230= CPU TIME MEGNIMED..
                                   .4148 SECONOS
      4240=
      4258=
C
      4264=
```

## APPENDIX E REGRESSION REG 3

```
166:1
110=9
:20=
                                                   81/15/82 18.25.57. PAGE
130=
               VOCELBACK COMPUTING CENTER
140=
               MORTHMESTERN UNIVERSITY
150=
               S.P.S.S. - - STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES
160=
176=
               VERSION 8.8 -- JUNE 13, 1979
188:
196=
266=
216=
229=
                     INITIAL REGRESSION
NZULT: MAXMACH: THE TAREA - TOGUMAY - PROTU
238= RUN NAME
240: VARIABLE LIST
                      ENG. CDC. MANMAT. TCOL. MANF
268: VAR LABELS
                      NZULT ULTIMATE LOAD FACTOR/
                      MAXMACH MAXIMUM MACH NUMBER/
276:
                      THTAREA TOTAL METTED AREA!
296=
                     TOGHMAX MAXIMUM TAKEOFF CROSS WEIGHT/
PROTO NUMBER OF PROTOTYPE AIRCRAFT/
296=
366:
3:0=
                     ENG ENGINEERING HOURS!
                     ODC OTHER DIRECT COSTS! MANMAT MANUFACTURING MATERIALS!
326:
33#:
344:
                      TOOL TOOLING!
35#=
                      MANE MANUFACTURING HOURS!
360= INPUT FORMAT
370= N OF CASES
                     FREEFIELD
                      UNKNOWN
386= COMPUTE
                      ENC=LN(ENC)
396= COMPUTE
                     SOC=LN. JOCI
466: COMPUTE
                     TOOL=LN(TOOL
418= CCMP.TE
                      HANNAT = LN (HANNAT)
428= COMPUTE
                      MANF=LN (MANF)
                      TUTAREA=LN:TUTAREA)
438= COMPUTE
446: COMPUTE
                      NZULT=LN(NZULT)
45#= COMPLITE
                      MAXMAC-=LN(MAXMACH)
                     TOCHMAX=LN(TOCHMAX)
468= COMPUTE
                     PROTO-LN(PROTO)
470= COMPUTE
488= RECRESSION
                     VARIABLES=ENG.NZULT.MAXMACH.TWTAREA
498=
                      TOCHMAX.PRCTO.MANHAT.MANF.TOGL.ODC
                      REGRESSION-ODC WIT- NIGHT MAXMACH . THTAREA
504:
510=
                      TOGUMAX, PROTO(1) /RESID=#
52#:
                      REGRESSION=HANHAT WITH NZULT-MAXMACH-TWTAREA
536=
                      TOGUMAX.PROTO(1:/RESID=6
54#±
                      REGRESSION-MANE WITH NZULT-MAXMACH-TWTAREA
550:
                      TOCHMAX.PROTO(1) /RESID=#
                      REGRESSION=TOOL WITH NZULT-MAXMACH-TWTAREA
544:
578=
                      TOCHHAX . PROTO(1) /RESID=#
                      REGRESSION=ENG WITH NZULT-MAXMACH-THTAREA
586=
                      TOCHMAX.PROTO(1) /RESID=0
5942
600= STATISTICS
                     ALL
618: READ INPUT DATA
628=
638: 99954696 CM NEEDED FOR RECRESSION
645:
650=
668=
670= END OF FILE ON FILE FAS
680= AFTER READING 8 CA
                         8 CASES FROM SUBFILE NOMAME
498=11MITIAL REGRESSION
                                                                          PAGE 2
                                                   01/15/82 10.25.57.
718= FILE - NONAME | (CREATED - $1/15/82)
```

```
720=
7382 + + + + + + + + FULTIPLE REGRESSION + + + + + + +
746=
750=
                               STANDARD DEV
                                               CASES
768: JAR!ABLE
776:
                    2.1832 -
788: ENG
                                      .1177
                    2.3453
790= NZULT
                                      .3926
                      .5996
866= HAXHACH
                     7.7125
                                      .2863
810= THTAREA
820= TOCHNAT
                                      .4486
                    16.7821
                     2.5899
                                      .9561
838= PR070
                                      .7666
                     4.2281
BAS: HANNA'
                                      , 6434
858= MANF
                     3.8523
                                      .5873
866= TOOL
                     1.5822
                                       .8963
870= OBC
                     4,9222
886=
89#=
766=
918 CORRELATION COEFFICIENTS.
926=
938= A VALUE OF 99.88888 IS PRINTED
948= IF A COEFFICIENT CANNOT BE COMPUTED.
954:
944=
976= A7IN T
                  .3528#
                            .47114
                   .56225
986= MAIMACH
                  -.26277
                           -.19:58
                                     -.86349
998= "HTAREA
                   .8148.
                                      .75346
                                              -,38334
1868= TOGUNAX
                            .33266
                                              .02555
                                                         .28287
                             .66465
                                      34115.
                   .52528
1818= PROTO
                                                                  .36699
                            .51392
                                      .75174
                                              -.2938;
                                                         .95456
1626= MANHAT
                   .85529
                            .56665
                                              - .26494
                                                         .8925#
                                                                   .2884:
                                      .73582
:838= MANF
                   .83728
                                                                   .79148
                             .44755
                                              -.63289
                                                         .52846
                                      146:
1848= TOOL
                   .82333
                                                                   77999
                                                         .71775
                            .33163
                                      .56525
                                              -.17724
:#50= 0DC
                   .87847
1868=
                                              THTAREA
                                                        TOGHMAX
                                                                 PRGTO
                            NZULT
                                     HAYMACH
:070=
                  ENG
:#84:
1698=
1166= HANF
                   .97588
1118= TOOL
                   .69:64
                             .71111
                   .74926
                                      .84538
                             .65829
1120= 3BC
1130=
                  MANKA?
                                     TOOL
1146=
:15#=
1168=
                                              #1/15/82 18.25.57. PAGE
1170=11KITIAL REGRESSION
1180=
 1198= FILE - NOMAME (CREATED - 81/15/82)
 1266=
 12252
                            OTHER DIRECT COSTS
 1230= DEP. VAR... CDC
 12462
                                                       .89629
 1258: HEAN RESPONSE
                          4.92217
                                       STD. DEV.
 1266=
 1278= VARIABLE(S) ENTERED ON STEP 1
                NUMBER OF PROTOTYPE AIRCRAFT
 1286= PROTO
 1298=
                    .7886 ANOVA
                                       DF SUM SQUARES MEAN SQ.
 1386= MULTIPLE R
                                                                  9.321
                    .6884 RECRESSION
                                                3.421
                                                         3.421
                                       1.
 1316= R SQUARE
                     .6058 RESIDUAL
                                                2.202
                                                           .367 SIG. .822
 :328= STD DEV
                                        6.
                    .5431 COEFF OF VARIABILITY
                                                12.3PCT
 1338= ADJ R SQUARE
 1346=
                                                       BETA ELASTICITY
 1356= VARIABLE
                     8
                           S.E. B
                                        F
                                             SIG.
 1360=
                                                                 .38473
                                                       .77999
 1370: PROTG
                     .731
                                       9.321 .022
                               .239
```

THE PARTY OF THE P

```
.389= CUN5 -AN
                J.BLO
                          .656
                                L1.244 .884
1396=
:486:
14:8:
1448= VARIABLE(S) ENTERED ON STEP 2
1450= TOGUMAX HAXINUM TAKEOFF GROSS WEIGHT
14462
                                 DF SUM SQUARES MEAN SU. F
2. 4.915 2.467 17.912
1470= PULTIPLE R
                .9368 ANGVA
                                2.
1480: R SQUARE
                 .8775 REGRESSION
1496= STB DEV
                 .0711 RESIBUAL
                                   5.
                                            .689
                                                   .138 515. .005
1500: ADJ R SQUARE .8285 COEFF OF VARIABILITY
                                           7.5PCT
1516=
1526: VARIABLE
                 B
                       S.E. B
                                   F SIG.
                                                BETA ELASTICITY
1536=
1546= PR070
                  .588
                          . 153
                                 14,793 .012
                                                 .62745
                                                         .38949
                                 18.987 .821
1558= TOCHMAI
                                                 .54874 1.36671
                1.686
                          .326
1566= CONSTANT -8.151
                                  3.798 .#6:
                         3.426
:576=:INITIAL REGRESSION
                                         81/15/82 18.25.57. PAGE
:588=
1598= FILE - NORAME (CREATED - $1/15/82)
1666=
1626=
1638= BEP. VAR... ODC
                        OTHER DIRECT COSTS
1646=
1650= VARIABLE(S) ENTERED ON STEP 1
              ULTIMATE LOAD FACTOR
1666= NZULT
:676=
                                  DF SUM SQUARES MEAN SQ.
1686= MULTIPLE R .9441 ANOVA
                                                 3.
1696= R SQUARE
                .8914 REGRESSION
                                          5.013
1766= STD DEV
                .3907 RESIDUAL
                                   4.
                                           .611
                                                   .153 510. .#21
1718= ABJ R SQUARE .8188 COEFF OF VARIABILITY
                                           7.9PCT
1728=
1736= VARIABLE
                                                 BETA ELASTICITY
                 E
                       S.E. B
                                   F 516.
1746=
                                 13.502 .021
1750= PROTO
                  .592
                                                 .63139
                          .161
                                                         .11:43
                                                 .49844 1.17784
1766= TOGUMAX
                  995
                                  7,580 ,852
                          .363
1778= NZULT
                  .952
                                                 .12561 .45073
                         1.332
                                   .511 .514
1786= CONSTANT
                -9.574
                         4.854
                                  5.577 .878
1796=
1866=
1818: F-LEVEL OR TOLERANCE-LEVEL INSUFFICIENT FOR FURTHER COMPUTATION.
:826=
1836=
1848=
1858: COEFFICIENTS AND CONFIDENCE INTERVALS.
1844:
1876= VARIABLE
                            95 PCT C.I.
                 В
:880=
1896= PROTO
                  .5919
                            .1447
                                    1.8391
1966= TOCHMAX
                  ,9951
                           -.5135
                                  2.6438
1918- NZULT
                  .9523
                          -2.7449
                                   4.6494
1928= CONSTANT
                -9.5736
                         -28.8293
                                  1.6828
1936=
1946:
1950: VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.
1966=
1976=
1986= NZULT
                1.77323
1998= TOCHMAX
                -.15886
                          .13199
2505= PR0T0
                 .96687
                         -.61626
                                  .62595
2818=
               NZULT
                        TOGUMAX PROTO
2020=
2636:
```

```
2040:
2050=11NITIAL REGRESSION
                                                #1/15/82 18.25.57. PAGE 5
2068=
2878= FILE - NOMAME (CREATED - $1/15/82)
2898= + + + + + + + + + HULTIPLE REGRESSION + + + + + + +
2166=
                             OTHER DIRECT COSTS
2118= DEP. VAR... ODC
2120=
2138=
2146: SUPMARY TABLE.
215#=
2168= STEP VARIABLE E/R
                             F MULT-R R-SQ CHANGE R OVERALL F 916.
                           9.321 .788 .688 .688 .738
18.987 .937 .878 .269 .718
.511 ,944 .891 .814 .332
2180= 1 PROTO
                                                              9.32. .821
2198= 2 TOGWMAX E
                                                             17.911 .965
                                                             $ ,945 . $2.
2296= 3 NZULT
2218=11NITIAL REGRESSION
                                                81/15/32 18.25.57.
                                                                      PAGE
 1126=
 1130= FILE - NONAME (CREATED - $1/15/82)
114#=
2250= + + + + + + + + + + + + ULTIPLE REGRESSION + + + + + + + +
11762
2280= RESIDUAL PLOT.
2298:
2386= Y VALUE Y EST. RESIDUAL -28D
                                                       f. f
                                                                         +250
2318=
          4,847
                    4.594
2326=
          2.931
2336=
                    3.666
                              -.576
2340=
          5.37:
                    5.263
                               .167
2358=
          4.551
                    5.231
                              -.680
2368=
          5.381
                    5.152
                               .149
2370:
          5.165
                    5.178
                              -.613
2388=
          5.312
                    5.148
                               .166
239#=
                    5.866
                               .835
2486=
2418= NOTE - (*) INDICATES ESTIMATE CALCULATED WITH HEARS SUBSTITUTED
2428= R INDICATES POINT OUT OF RANGE OF PLOT
2436=
744Ez
2450: NUMBER OF CASES PLOTTED
2460= NUMBER OF 2 S.D. OUTLIERS
                                                 # PERCENT OF THE TOTAL
26,00
2486= VCN NEUMANN RATIO 0.88157
                                            DURBIN-MATSON TEST 1.69638
2494:
2500: NUMBER OF POSITIVE RESIDUALS
2516- NUMBER OF MEGATIVE RESIDUALS
2520: NUMBER OF RUNS OF SIGNS
2508=
2346: MORMAL APPROXIMATION TO SIGN DISTRIBUTION IMPOSSIBLE. 2356: USE A TABLE FOR EXPECTED VALUES.
2566=: INITIAL RECRESSION
                                                81/15/82 18.25.57. PAGE 7
2500= FILE - NOMANE (CREATED - 81/15/02)
2600= • • • • • • • • • • HULT: F.E. REGRESS: 0 N = • • • • • • •
26160
2628= DEP. WAR... MANNAT
                            MANUFACTURING MATERIALS
2630
2646: NEMI RESPONSE
                                        STD. DEV.
2450-
1448= VARIABLE(S) ENTERED ON STEP 1
2678= TOCUMAL MAXIMUM TAKEDEF CROSS WEIGHT
                                        OF SUM SQUARES MEAN SQ.
2690- MATTPLE R
                   .9544 AMOVA
```

1

```
3....
L/80= K SWUARE
                 .Yise REUNESTION
                                          11.145
                                                           54.55
                                 1.
                                           .385
                 .2253 RESIDUAL
                                                    .05. 3:5. .200
2716= STB DEV
                                   6.
2728= ADJ R SQUARE .8964 COEFF OF VARIABILIT*
                                           5.3907
2736s
                                                BETA ELASTICITY
2748: VARTABLE
                  B
                        S.E. B
                                   F
                                        316.
2750=
1766= TOGWAY
                1.496
                          .196
                                 61.557 .666
                                                 .95456 3.79852
2778= CONSTANT -11.832
                       2.849
                                 33.362 .861
2786=
2796=
2866=
28262
2836= VARIABLE(S) ENTERED ON STEP 2
2848= NZULT
           ULTIMATE LOAD FACTOR
2856=
2868= MULTIPLE R .9776 ANGVA
                                  DE SUN SQUARES MEAN SQ.
                .9545 REGRESSION 2. 3.274 1.637 1766 RESIDUAL 5. 156 .831
                                                        $2,583
2870= R SQUARE
2880= STO DEV .1766 RESIDUAL 5.
2890= ADJ R SQUARE .9364 CGEFF OF VARIABILITY
                                                   .021 116. .002
                                           1,200
2966=
2918= VARIABLE
                                  F SIG.
                                                BETA ELASTICITY
                 2
                       S.E. &
2926=
                1.375
1930= TOCHMAX
                          .:58
                               75.952 .806
                                                 .85111 1.58621
2946= NZULT
                1.314
                          .60:
                                 4.776 .88:
                                                 .22821 .72867
1958= CONSTANT -13.677
                         1.814
                                 56.844 .86:
296#=:INITIAL REGRESSION
                                         $1.15/82 18.25.57. PAGE
2970=
2988= FILE - NONAME (GREATED - $1/15/82)
2996=
BOOG= + + + + + + + + + + PULTIPLE | REGRESSION + + + + + + +
3616:
3828= DEP. VAR... MANNAT MANUFACTURING MATERIALS
3838=
3646: VARIABLE(S) ENTERED ON STEP 3
3050= PRQT0
            NUMBER OF PROTOTYPE AIRCRAFT
3068=
3078: MULTIPLE R .9838 ANGVA
                                 BF SUM SQUARES MEAN SQ.
                                3. 3.314 1.185 58.275
                .9663 REGRESSION
388#= R 3GUARE
                 .1899 RESIDUAL
                                   i,
                                           .115
                                                    .829 516. .861
3696: STD DEV
3186= ADJ R SQUARE .9411 COEFF OF VARIABILITY
                                          4.6P07
3::8=
                                  F 510.
                                                BETA ELASTICITY
3:20= VAR:ABLE
                 В
                       5.E. B
5130=
3146= TOCHMAX
                1.323
                                                 .84794 3.37423
                           .158
                                 76,157 .881
3150= NZULT
                                 5.221 .082
1.491 .302
                                                        .74895
                1.336
                          .579
                                                 .22450
3148= PROTO
                 . #83
                          .878
                                                 .11323
                                                         . 45676
3178= CONSTANT -13.385
                         1.763
                                 57,659 .662
3186=
3196:
3266=
32282
3230= VARIABLE(S) ENTERED ON STEP 4
3249= TWTAREA TOTAL WETTED AREA
3256=
3268= MULTIPLE R .9846 ANOVA
                                  DF SUM SQUARES MEAN SQ.
                                 4. 3.325 .831
                                                         23.816
3270: R SQUARE
                 .9695 REGRESSION
                .1868 RESIDUAL
3284: STD BEV
                                           .165
                                                    .835 SIG. .813
                                   3.
3298= ADJ R SQUARE .9287 COEFF OF VARIABILITY 4.4PCT
3396=
3316: VARIABLE
                 3
                        S.E. B
                                   F SIC.
                                                 BETA ELASTICITY
3328=
3336: TOCHMAX
                 1.365
                          .:89
                                 51.969 .866
                                                 .87466 3.48957
                                  4.311 .129
                                                         .73385
3346= NZULT
                1.323
                                                 .22238
                          .637
3350= PROTO
                 .876
                          .678
                                   .959 .486
                                                 .:84.6
```

```
.274
                                      .307 .618
3366= TUTAREA
                   .153
                                                     .86128 .2798.
337#= CONSTANT -14.969
                           3.452 18.799 .823
3080=1INITIAL REGRESSION
                                            #1/15/62 18.25.57. PAGE 9
3396=
3490= FILE - NONAME (CREATED - 61/15/82)
341#=
3436=
3448= DEP. VAR... MANMAT
                          MANUFACTURING MATERIALS
3450=
3466: VARIABLE(S) ENTERED ON STEP 5
3478= MAXRACH
               MAXIMUM MACH NUMBER
3486=
3498= MULTIPLE R
                   .9861 ANOVA
                                     DF SUM SQUARES MEAN SQ.
                                   ur 58M Si
5.
                                                      .667 14.843
3500= R SQUARE
                   .9723 REGRESSION
                                              3.335
3516= STD DEV
                   .2179 RESIDUAL
                                               .895
                                                         .847 910. .868
3528= ABJ R SQUARE .983: COEFF OF VARIABILITY
3530=
3548= VARIABLE
                                                     BETA ELASTICITY
                          S.E. D
                                           SIC.
3550=
                                                             3,77387
3564: TOGUNAY
                  1.486
                             .336
                                    19.341 .848
                                                     .9487.6
                  1,457
                                                     .24489
3576= NZULT
                                           .218
                                                              .888:3
                                     3.318
                             .866
3586= PROTO
                                                              .84546
                   .874
                             .89:
                                      .664 .581
                                                     .:0131
                   .214
3598= TUTAREA
                                      .377 .682
                                                             .37125
                             .349
                                                     .0857#
3688= PAIMACH
                  -..48
                             .371
                                      .285
                                           .695
                                                    -. 694;5
                                                            -.01380
3618= CONSTANT
                 -16.891
                            5.85#
                                     8.307 .182
3626=
3636=
3648= ALL VARIABLES ARE IN THE EQUATION.
3650=
3666=
3476s
3680: COEFFICIENTS AND CONFIDENCE INTERVALS.
3496×
3766= VARIABLE
                   €
                              95 PCT C.I.
37:0=
3728= TOCHMAX
                  1.4799
                              .#32#
                                       2.9277
3730= NZUL"
                  1.4569
                             -1.9846
                                       4.8984
3748= PR013
                   .0742
                             -.3:75
                                       , 4655
3756= THTAREA
                   ,2145
                            -1.2891
                                       1.7:81
3768: MAXRACH
                  -.1678
                            -1.7622
                                      1.4265
3776= CONSTANT
                -16.5966
                           -42.8682
                                      8.2790
3786:
3794:
3860: VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.
3816=
3828=
3836= NZULT
                  .63975
                           .13730
3846= MAXPACH
                 -.18954
3850: THTAREA
                  .#3158
                          -.05030
                                     .12212
3846: TOCHMAX
                  .02331
                          -.69448
                                     .86273
                                              .11323
3076: PROT6
                                                        .00829
                  .66:69
                           .60177
                                   -.66516
                                             -.86747
3000±
3076±
                                  TWIAREA
                NZULT
                          MAIMACH
                                            TOGUNAX PROTO
3986=
39:0=
3928=11NITIAL REGRESSION
                                            $1/15/82 18.25.57. PAGE 18
3948: FILE - HOMANE (CREATER - $1/15/82)
3956=
3960x * * * * * * * * * * * HULTIPLE REGRESSION * * * * * * * * *
3976:
3906= BEP. VAR... MANNAT
                          HANGFACTURING MATERIALS
3998=
4900 z
48:9: SURMARY TABLE.
```

```
48/92
4636: STEP VARIABLE E/R
                       F MULT-RIR-SQ CHANGE R OVERALL FISIG.
4848:
                        61.557 .955 .911 .911 .955
4858= 1 TOGUMAX E
                                                       61.557 .888
4666=
      2 AZULT
                         4,776 ,977 ,955 ,843 ,514
                                                       51.583 .888
4876= 3 PROTO
                         1.491 .983 .966 .012 .367
                                                       38.275 .#81
4888= 4 TWTAREA E
                          .387 .985 .969 .883 -.294
                                                      23.818 .813
4898= 5 MAXMACH E
                                                       14.841 .868
                          .285 .986 .972 .883 .752
4166=1INITIAL REGRESSION
                                           81/15/82 18.25.57.
                                                                FACE
4116=
4128= FILE - NONAME (CREATED - 81/15/82)
4136=
ALABO A A A A A A A A A A A A B D L T I P L E . R E G R E S 3 I G B A A A A A A A A A
4156s
4168=
4176= RESIBUAL PLUT.
418#=
419#=
       Y VALUE Y EST. RESIDUAL -250
                                                 ŧ.ŧ
                                                                  +282
4266=
4218=
         4,251
                  4.236
                            .814
                                                  ::
                  2,997
         1.668
4226=
                            4:1
                  4.759
4238=
        4,861
                            .641
4746=
         4.662
                  4.503
                            .168
125#=
        4.268
                  4.522
                           -.254
4268=
         3.857
                  3.819
                            .#37
4276=
        3.73:
                  3,763
                           • .833
428#:
                            .822
        5.246
                  5.224
4298=
4300: NOTE - (*) INDICATES ESTIMATE CALCULATED WITH HEARS SUBSTITUTED
           R INDICATES POINT OUT OF RANGE OF PLOT
4316=
432#=
£136:
4340= NUMBER OF CASES PLOTTED
                                  8.
4056= NUMBER OF 2 S.D. OUTLIERS
                                   ₫ jR
                                           # PERCENT OF THE TOTAL
4366=
4278= VON NEUMANN RATIO 3.35496
                                       DURBIN-MATSON TEST 1.93554
1380=
4398= NUMBER OF POSITIVE RESIDUALS
4488= NUMBER OF NEGATIVE RESIDUALS
4418= NUMBER OF RUNS OF SIGNS
4428:
4430= NORMAL APPROXIMATION TO SIGN DISTRIBUTION IMPOSSIBLE.
4446= USE A TABLE FOR EXPECTED VALUES.
4458=11NITIAL REGRESSION
                                           #1/15/82 19.25.57. PAGE 12
4468=
4478= FILE - NONAME (CREATED - $1/15/82)
4506:
                         MANUFACTURING HOURS
4518= DEP. VAR... MANF
4520=
                                                   .64337
4536: MEAN RESPONSE
                       3.85231
                                   STD. DEV.
4544:
4550= VARIABLE(S) ENTERED ON STEP 1
4566= TOGUMAX MAXIMUM TAKEOFF CROSS WEIGHT
4578=
4586: MULTIPLE R
                 .8925 ANOVA
                                    BF SUM SQUARES MEAN SQ.
                                                     2.368 23.493
4596= R SQUARE
                  .7966 REGRESSION
                                   1.
                                           2.398
                  .3134 RESIDUAL
                                                       .078 SIG. .083
4686= STD BEV
                                              .589
                                     6.
4616= ADJ R SQUARE .7627 COEFF OF VARIABILITY
                                             8.1PCT
4428=
4630= VARIABLE
                  1
                                    F
                                       sic.
                                                   BETA ELASTICITY
                         S.E. $
4644=
4656: TOCHMAX
                 1.280
                            .264 23.493 .663
                                                   .89256 3.58272
4668= CONSTANT
                 -9.949
                          2.856
                                   12.196 .613
```

```
46882
46962
4716=
4728= VARIABLE(S) ENTERED ON STEP 2
4730: KZIJL"
             ULTIMATE LOAD FACTOR
4746:
4750: MULTIPLE R
                .9353 ANOVA
                                BF SUM SQUARES MEAN SQ.
                                2.
5.
                                               1.267 17.465
4766= R SQUARE
                .8748 REGRESSION
                                        2,535
4770= STD DEV
                .2694 RESIDUAL
                                         .363
                                                  .873 SIG. .886
4780= ABJ R SCHARE .8247 COEFF OF VARIABILITY
                                         7.SPCT
4796=
4866= VARIABLE
                      S.E. B
                                      SIG.
                                              BETA ELASTICITY
4818=
                               22.379 .665
                                               .79384 1.18665
4828= TOCHMAX
                1.139
                         .241
                         ,918
                                3.123 .137
                                               .29657
                                                      .98725
4836: NZULT
                1.622
4846= CONSTANT -12.227
                                19.528 .887
                        2.767
4856=LINITIAL REGRESSION
                                       $1/15/82 18.25.57. PAGE II
4:48:
4870= FILE - NOMAME (CREATED - $1/15/82)
4336=
1966=
4918- BEP. VAR... MANE
                       MANUFACTURING HOURS
4926=
4938= VARIABLE(S) ENTERED ON STEP 3
4948= THTAREA TOTAL JETTED AREA
1750=
4966= MULTIPLE R
                AVONA 2829.
                                DF SUM SQUARES MEAN SQ.
                                        2.551
4970= R SQUARE
                .8864 REGRESSION
                                3.
                                                 .858 9.816
                                          .346
498#= STD DEV
                .2943 RESIDUAL
                                 4.
                                                  .025. .016 780.
4998= ABU R SQUARE .7987 COEFF OF VARIABILITY
                                         7.6P27
5866:
50:0= VARIABLE
                8
                      S.E. B
                                      SIG.
                                              BETA ELASTICITY
582#=
5838: TOCHMAX
                1.184
                         .283
                                17.468 .814
                                               .82592
                                                     3.315#6
Seie MZUL"
                1.608
                                2.571 .184
                                               .29414
                                                      379;
                        1.663
5650= THTAREA
                 .187
                         436
                                 .139 .687
                                               .88132
                                                       .3736:
5868= CONSTANT
              -14.13#
                        5.324
                                7.643 .857
5678=
5888:
56962
511#=
5128= VARIABLE(S) ENTERED ON STEP 4
5130= PR010
           MUMBER OF PROTOTTPE AIRCRAFT
5:42
                                DF SUM SQUARES MEAN SQ.
5158: MULTIPLE R
                .9398 ANOVA
                .8817 REGRESSION
                                        2.555
                                                        5.59:
5:60= R SQUARE
                                 4.
                                                 .639
5178: STD DEV
                .3380 RESIDUAL
                                         .343
                                                  .114 516. .894
5188= ABJ R SQUARE .7246 COEFF OF VARIABILITY
                                         8.SPCT
5196=
                                 F
                                              BETA ELASTICITY
5200= VARIABLE
                                      SIG.
                B
                       S.E. B
5216:
                1,145
                                1:.572 .642
                                               .81227
                                                     3.26065
5228= TOCHMAN
                          . 342
5230= NZULT
                1.616
                        1.153
                                1.966
                                      . 255
                                               .29557
                                                       .98392
5246= THTAREA
                .173
                         .499
                                 .126 .752
                                               .87529
                                                       .34572
5250= PROTO
                 .826
                         .14:
                                  .833 .867
                                               .93818
                                                       .81727
5268= CONSTANT
              -13.898
                        6.245
                                 4.953 .112
5276=11NITIAL RECRESSION
                                       $1/15/82 19.25.57. PAGE 14
5280=
5298= FILE - NOMANE (CREATED - 81/15/82)
5366 z
5326=
5338: BEP. VAR... HAMF
                        MANUFACTURING HOURS
```

```
5356= VARIABLE(S) ENTERED ON STEP 5
5368= MAXMACH MAXIMUM MACH NUMBER
5378:
                                     BF SUM SQUARES MEAN SQ. 5. 2.558 .512
5388= MULTIPLE R
                  .9396 ANOVA
                   .8828 REGRESSION
                                                         .512
                                                                 3.813
5390= R SQUARE
5466= STB DEV
                   .4120 RESIDUAL
                                                .346
                                                         .178 $10. .268
5418= ABJ R SQUARE .5898 COEFF OF VARIABILITY
                                              18.7PCT
5428=
5430= VARIABLE
                                           SIG.
                                                     BETA ELASTICITY
                          S.E. B
5446=
5450= TOCHMAX
                  1.236
                             .636
                                     3.739
                                                     .35779
                                                             3.44333
                                           .193
5468= NZULT
                                     1.252
                  1.692
                           1.512
                                           .379
                                                     .38947
                                                             1.03028
5476: THTAREA
                                      .#99
                                           .783
                                                     .89856
                   . 208
                             .661
                                                              .41566
548#= PROTO
                   .424
                             .:72
                                      .638
                                           .966
                                                     .83835
                                                              .61445
5498: MAXMACH
                  -.#95
                             .781
                                      .$18.
                                           .984
                                                    -.058:4
                                                             -.61483
5566= CONSTANT
                 -14.989
                           11.566
                                     1.807 .398
55:0=
5526=
553#= ALL VARIABLES ARE IN THE EQUATION.
555#=
556#=
5570= COEFFICIENTS AND CONFIDENCE INTERVALS.
5584=
559#= VARIABLE
                              95 PCT 0.1.
                   E
5680=
561#= TOCHMAX
                  1.2303
                             -1.5971
                                       3.9677
5628= NZULT
                  1.6922
                             -4,8145
                                       6.1989
5639= THTAREA
                   .2977
                             -2.6351
                                       3.6565
564#= PR0"3
                   .6245
                             -.7160
                                        .7658
5650= MAXMACH
                   -.6953
                             -3,1897
                                       2,9:91
5666= CONSTANT
                 -14.9894
                            -62.5767 32.5988
5676=
5688=
5690= VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.
5766=
57:#=
572#= NZULT
                 2.29484
5738= MAXMACH
                  -.39:56
                           .49831
5748= THTAREA
                                     .43653
                           -.17980
                  .11289
                                               .48476
5756= TOCHMAY
                   .68331
                           -.33431
                                     .22423
5768= PROTG
                                                        .82962
                   .66391
                            .96433
                                    -.61822
                                             -.82669
5776=
5786=
                 NZULT
                          MAXMACE THTAREA TOGHNAX PROTO
5798=
5866=
58:0=:INITIAL REGRESSION
                                             #1/15/82 18.25.57.
                                                                PAGE :
5825=
583#= FILE - MONAME (CREATED - #1/15/82)
5844=
5844:
5876= DEP. VAR... MANF
                           HANUFACTURING HOURS
5886=
58982
5996= SUMMARY TABLE.
5918=
                           F MULT-R R-SQ CHANGE R OVERALL F SIG.
5928: STEP VARIABLE E/R
5938=
594#=
      1 TOCHMAX
                         23,493 ,893
                                      ,797
                                           .797 .893
                                                                . 863
                   E
       2 WZULT
5956=
                                      .875 .878 .541
                                                         17.465 .886
                   Ε
                          3.123 .935
                                      .886
                                                         9.814 .824
      3 THTAREA
                           .189 .938
                                           .064 -,245
COAR'S
                   E
                           .633 .939
                                                         5.591 .694
                                      .882 .061 .288
5976: 4 PROTO
                   Ε
5980: 5 MAXMACH
                   E
                           .818 .948
                                      .883
                                            .001 .736
                                                         3.013 .268
5999=:INITIAL REGRESSION
                                             #1/15/81 19.25.57.
                                                                  PAGE 16
```

```
6818= FILE - MONAME (IREATED - 81/15/82)
£$28=
5648=
6656:
6066= RESIDUAL PLOT.
6676=
6888:
6898:
       Y VALUE Y EST. RESIDUAL -2SD
                                                6.8
                                                                +250
6190=
                 3.993
                           .898
6116=
        2.893
                 2,798
                           , 665
6120=
         4.4.2
                 4.285
                           .126
6130=
         4.297
                           .182
                 4.115
6146:
        3.688
                          -.526
                 4.129
£138=
        3.526
                          .$75
                 3.451
                 3.363
616#=
        3.336
                          -.827
6:76=
        4,745
                 4.685
                           .648
6130=
6198= NOTE - (+) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
6260=
           R INDICATES POINT OUT OF RANGE OF PLOT
li:1:
6228=
6298: NUMBER OF CASES PLOTTED
                                 8.
6246: NUMBER OF 2 S.D. OUTLIERS
                                  # CR
                                          # PERCENT OF THE TOTAL
A258=
6266= VON NEUMANN RATIO 3.66567
                                      BURBIN-WATSON TEST 2.62996
6276=
6280= NUMBER OF POSITIVE RESIDUALS
6298= NUMBER OF NECATIVE RESIDUALS
6389= NUMBER OF RUNS OF SIGNS
63:8=
6326- MORMAL APPROXIMATION TO SIGN DISTRIBUTION IMPOSSIBLE.
5338= USE A TABLE FOR EXPECTED VALUES.
6340=11NITIAL REGRESSION
                                          #1/15/82 18.25.57. PAGE 17
6356=
6368= FILE - NCNAME (CREATED - $1/15/82)
6376=
6380 - + + + + + + + + NULTIPLE REGRESSION + + + + + + + +
639#=
6488= BEP. VAR... TOOL
                         TOOLING
6416=
6428= HEAN RESPONSE
                       1.58223
                                   STB. DEV.
643#=
6448= VARIABLE(S) ENTERED ON STEP 1
6450= PRCTO
              NUMBER OF PROTOTYPE AIRCRAFT
6468=
6478= MULTIPLE R
                                   DF SUN SQUARES HEAN SQ.
                 .7914 ANOVA
6480: R SQUARE
                 .6263 RECRESSION
                                   1.
                                          1.512
                                                   1.512
                                                            :0.356
6496= STD DEV
                 .3878 RESIDUAL
                                             .982
                                                     .156 SIG. .019
6500= ADJ R SQUARE .5640 COEFF OF VARIABILITY
                                           24.5PCT
6518=
6528= VARIABLE
                                         SIG.
                                                  BETA ELASTICITY
                  1
                        S.E. B
6530=
4548= PROTO
                   .486
                           .153
                                  10.054 .819
                                                  .79148
                                                         .79578
6550= CONSTANT
                  .323
                           .425
                                    .592 .471
4544:
6576=
SALE VARIABLE(S) ENTERED ON STEP
6620= NZULT
             ULTIMATE LOAD FACTOR
4436×
6648= MULTIPLE R
                  .8854 ANOVA
.7846 REGRESSION
                                   DF SUN SQUARES MEAN SQ.
                                                       947 9.872
                                   2.
6650= R SQUARE
                                                      ,947
                                            1.893
```

```
BAARS S. II UEV
                 . JAJE MED. BUML
                                                    ...............................
6676: ADJ R SQUARE .6975 COEFF OF VARIABILITY 26.4PCT
AABE:
                                                 BETA ELASTICITY
6698= VARIABLE
                  8
                        S.E. B
                                   F
                                        Sic.
6780=
                                                  .76559 .76983
6719= PR0T3
                  .476
                           .128
                                  13.568 .614
6728= MZUL"
                 1.986
                                  3.649 .114
                                                  .39796 2.94413
                          1.646
6738= CONSTANT -4,294
                          2.442
                                   3.691 .139
                                         61/15/52 18.25.57. PAGE 18
6740:: INITIAL RECRESSION
6758=
6768= FILE - NOMAME (CREATED - 01/15/82)
L776=
6798=
6866= BEP. VAR... TOOL
                         TOOLING
6816=
6828= VARIABLE(S) ENTERED ON STEP 3
6836= TOGUMAX PAXIMUM TAKEDEF CROSS WEIGHT
634#=
                 .9#75 ANOVA
                                   DE SUM SQUARES MEAN SQ.
685#= MULTIPLE R
                                                  .665 6.22
                 .8235 REGRESSION
                                 3.
                                           . 989
6860= R SQUARE
6876= STB CEV
                 .3265 RESIDUAL
                                   4,
                                            .426
                                                      .187 510. .655
                                           28.6PCT
4888= ABJ R SQUARE .6911 COEFF OF VARIABILITY
6896=
6966= VARIABLE
                  8
                        S.E. B
                                    F
                                        SIG.
                                                  BETA ELASTILITY
691#=
                  , 435
                                  18.458 .632
6928= PR0TO
                           .135
                                                  .78628
                 1.641
                                                  .32865 1.40174
6938= NZULT
                                  2,174 .214
                          1.113
5946= TOCHMAX
                  .287
                                    .895 .398
                                                  .21936 1.95723
                           , 364
6956= CONSTANT
                -6.489
                          3,387
                                   3,679 .128
-9464
4978s
£986=
7010= VARIABLE(S) ENTERED ON STEP 4
7828= THTAREA TOTAL WETTED AREA
7838=
7640= MULTIFLE R
                 .9184 ANOVA
                                  DE SUM SQUARES MEAN SQ.
                                                             F
                                  4,
                 .8268 REGRESSION
                                                     .566
7656= R 59UARE
                                           2.56:
                                                             3.638
                                                     .138 515. .159
7866= STD DEV
                 .3713 RESIDUAL
                                             ,4;4
                                    3.
7676= ADJ R SQUARE .6664 COEFF OF VARIABILITY 23.5POT
7686:
7896= VARIABLE
                  В
                        S.E. B
                                   F
                                        SIC.
                                                 BETA ELASTICITY
7166=
7::#= PR0T0
                  ,128
                           . 155
                                  7.635 .876
                                                  .69655
                                                          .76841
                 1.627
                                   1.651 .289
                                                  .32589
                                                         2.41136
7126= NZULT
                          1.265
7136= TOCHMAY
                 .333
                          .376
                                   .782 .442
                                                  .25468 2.26768
7148: THTAREA
                  .167
                           .549
                                    .692 .781
                                                  .67963
                                                          .81318
7159= CONSTANT
                                   1.434 .317
                 -8.215
                          6.86
7168=11NITIAL REGRESSION
                                          81/15/82 18.25.57. PAGE 19
7176=
7180: FILE - NONAME (CREATED - 01/15/82)
7196=
7299= + + + + + + + + + HULTIPLE REGRESSION + + + + + + + +
7216=
7226= DEP. VAR... TOOL
7236=
7240= VARIABLE(S) ENTERED ON STEP 5
7258- MAINACH MAXIMUM MACH NUMBER
7268=
                                   DF SUM SQUARES MEAN SQ.
                                                             F
7270= MULTIPLE R
                 .9116 AMOVA
7286= R SQUARE
                  .8311 RECRESSION
                                   5.
                                           2.007
                                                     .481
                                                             1.968
                 .4518 RESIDUAL
7298= STB DEV
                                             .448
                                                      .204 SIG. .370
7388= ADJ R SQUARE .4887 COEFF OF VARIABILITY
                                           28.5PC
7316=
```

```
7020: VARIABLE
                         S.E. B
                                          Sic.
                                                    BENA ELASTICITY
                  Ŀ
7336=
7348= PPGTG
                   .426
                            .189
                                    5.166 .152
                                                    .69388
                                                             .69773
                           1.658
7050: NZULT
                                    1.687 .467
                                                    .34621
                                                            2.56167
                  1.728
                                     .362 .688
                                                    .32868
                                                            1.86262
736#= TOCHRAY
                   .420
                            .697
7378= THTAREA
                                                           1.04816
                                     .887 .796
                   .213
                            .724
                                                    .10185
7380= MAXMACH
                                                            24817
                                     .027 .884
                  -.127
                            .748
                                                   -.#8496
7398= CONSTANT
                 -9.671
                          12.123
                                     454.
                                          .589
7496=
7416:
7428= ALL PARIABLES ARE IN THE EQUATION.
 7430=
7446=
7456=
7468= COEFFICIENTS AND CONFIDENCE INTERVALS.
7476=
748#= VARIABLE
                              95 PCT 1.1.
7496=
7500= FR0T0
                   .4263
                             -.3854
7518= NZULT
                  1.7282
                            -5,4837
                                      8.8661
7528= TOCHMAX
                   1198
                            -2.5884
                                      3,4202
7530= TATAREA
                   .2134
                            -2.9625
7549= MAXMACH
                  -.1271
                            -5.4311
                                      3.1769
7556= CONSTANT
                 -9.6786
                           -61.83#2
7568=
7586: VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.
7598=
7686=
                 2.74741
7618= NZULT
7628= MAXMACH
                 -.47842
                           .58966
7636: TATAREA
                  .13582
                          -.218#1
                                     .52444
7640= TOCUMAX
                  .15689
                          - . 48484
                                    .25939
                                              .48627
7650= PROTO
                  .66469
                           .88768
                                   -.02189
                                             - .83286
                                                       .03558
766#=
                NZULT
                         MAXMACH THTARES TOGHMAX FROTO
7676=
7686=
7496=
7766=11NITIAL REGRESSION
                                           #1/15/82 1#.25.57. PAGE 1#
77:4:
7728= FILE - NONAME (CREATED - 61/15/82)
7736=
7746= 4 4 4 4 4 4 4 4 4 4 MULTIPLE REGRESSION * * * * * * * * *
7756=
776#= DEP. VAR... TOCL
                          TOOLING
77762
7789:
7796: SUMMARY TABLE.
78862
7816: STEP VARIABLE E/R
                          F MULT-R R-SQ CHANGE R OVERALL F SIG.
7826*
                         18.856 .791 .628 .626 .791
                                                       18.856 .819
7836=
      1 PROTO
                         3.645 .885 .784 .158 .448
                                                        9.872 .822
7844:
      2 NZULT
                  Ε
7856=
                          .895 .967 .823 .646 .518
      3 TOCHMAN E
                                                        6.220 .855
      4 THTAREA
                           .892 .918 .829 .865 -.633
                                                        3.636 .159
7878: 5 MAXMACH
                  E
                           .627 .912 .831 .602 .466
                                                        1.968 .370
7886=: INITIAL RECRESSION
                                            @1/15/82 10.25.57.
7988: FILE - NOMANE (CREATED - $1/15/82)
7916=
7936=
7948:
7958: RESIBUAL PLOT.
7966=
79782
      Y VALUE Y EST. RESIDUAL -25D
                                                                   +256
```

```
/488:
7996:
         1.805
                  1.576
                            .229
6666 =
          .285
                           -.827
                  .::2
8616:
         .....
                  1.633
                            .21:
8626=
         1.69#
                  1.768
                           -.498
8636:
         1.22:
                  1.754
                           -.533
8848=
         2.987
                  2.612
                            .075
8858=
         1.69#
                  1.639
                            .45:
8060=
         2.836
                  1.745
                            .691
2076=
8888= NOTE - (4) INDICATES ESTIMATE CALCULATED WITH REANS SUBSTITUTED
£696=
           R INDICATES POINT OUT OF RANGE OF PLOT
8186=
8:16=
8126= NUMBER OF CASES PLOTTED
                                  8.
8:30= NUMBER OF 2 S.D. DUTLIERS
                                            # PERCENT OF THE TOTAL
                                   # OR
8:44:
8158= VON NEUMANN RATIO 2.18191
                                       DURBIN-WATSON TEST 1.18846
616#=
8178= NUMBER OF POSITIVE RESIDUALS
8188= NUMBER OF NEGATIVE RESIDUALS
8198= NUMBER OF RUNS OF SIGNS
8266=
8218: MORMAL APPROXIMATION TO SIGN DISTRIBUTION IMPOSSIBLE.
8228= USE A TABLE FOR EXPECTED VALUES.
8236=11NITIAL REGRESSION
                                           $1/15/82 18.25.57. PAGE 22
R74#:
825#= FILE - NONAME (CREATED - #17.5/82)
2246:
827#= * * * * * * * * * * * * ULTIPLE REGRESSION * * * * * * * *
:186=
8298= DEP. VAR... ENG
                         ENGINEERING HOURS
= 0053
8310= MEAN RESPONSE
                       2.16516
                                 STD. DEV.
                                                   .61793
8324=
*833#= VARIABLE(S) ENTERED ON STEP 1
5345= TOCHMAX MAXIMUM TAKEOFF GROSS WEIGHT
£356=
836#= MULTIPLE R
                 .8:48 ANGVA
                                    OF SUM SQUARES MEAN SQ.
                                                    1.775 11.853
8370= R SQUARE
                  .6639 RECRESSION
                                         1.775
                                    1.
938#= STB DEV
                  .3869 RESIDUAL
                                                      .158 576. .814
                                              .898
                                     6.
9398= ABJ R SQUARE .6679 COEFF OF VARIABILITY
                                            18.4P(*
8466=
8416= VARIABLE
                  В
                                    F 516.
                                                   BETA SLASTICITY
                         S.E. B
8426=
                 :.122
                                  11.853 .614
8430: TOCHNAY
                            .326
                                                   .81481 5.74873
                                   8.875 .029
8448= CONSTANT
                 -9.997
                           3.518
8456=
3444:
8476=
8496=
8566= VARIABLE(S) ENTERED ON STEP 2
             NUMBER OF PROTOTIPE AIRCRAFT
8519= PROTO
8574:
                                    DF SUM SQUARES MEAN SQ.
8530= MULTIFLE R
                 .87:1 AMOVA
                                                              7.862
8546: R SQUARE
                  .7587 RECRESSION
                                    2.
                                            2.628 1.614
8556= STD DEV
                  .359: RESIDUAL
                                     5.
                                              .645
                                                      .129 SIG. .829
8568= ABJ R SQUARE .6622 COEFF OF VARIABILITY 17.1PCT
 8576=
8586= VARIABLE
                         S.E. B
                                          SIG.
                                                   BETA ELASTICITY
859#=
8666= TOCHMAX
                   .998
                            .315
                                   18.604 .825
                                                   .72426 5.18991
                                    1.965 .228
8616= PROTO
                           .148
                  .267
                                                   .32897
                                                            .25521
8628= CONSTANT
                 -9.189
                           3.315
                                    7.682 .839
863#=1INITIAL REGRESSION
                                           #1/15/82 18.25.57. PAGE 23
```

```
8650= FILE - NOMARE (CREATED - 01/15/82)
8668=
8678 * * * * * * * * * * * * DLTIPLE REGRESSION * * * * * * * * * * * * *
:0843
8698= BEP. VAR... ENG
                         ENGINEERING HOURS
8766=
8718= VARIABLE(S) ENTERED ON STEP 3
8728= MAXMACH MAXIMUM MACH NUMBER
8748: MULTIPLE R
                  .8874 ANOVA
                                    DF SUM SQUARES MEAN SQ.
                                  3. 2.:05 .782 4,939
                  .7874 RECRESSION
8750= R SQUARE
                  .3769 RESIDUAL
                                              .568
                                                      .142 115. .078
8744: STD DEV
                                    Ł.
8778= ADJ R SQUARE .6220 COEFF OF VARIABILITY 17.5PCT
8784z
                                                   BETA ELASTICITY
8790= VARIABLE
                  В
                         S.E. B
                                    F
                                          SIC.
8866=
                                                  .91836 6.47931
.32873 .25581
-.25753 -.11547
                 1.165
8816= TOCHMAY
                           .492
                                    6.612 .062
                                   1.782 .253
.548 .583
8326= PRC*3
                 .197
                           .:55
9836= MAXMACH
                - , 445
                            .552
                                    5.593 .877
8846= CONSTANT -11.829
                           5.862
8850=
:0683
8876=
2294:
8986= VARIABLE(S) ENTERED ON STEP 4
8916= NZULT
               ULTIMATE LOAD FACTOR
8920=
                                   BF SUM SQUARES MEAN 50. F
4. 1.188 .545 3.317
8938= MULTIPLE R
                  .9831 ANOVA
8948= R SQUARE
                  .8156 REGRESSION
                                   3.
8956= STD DEV
                  .4653 RESIBUAL
                                             .493
                                                      .164 516. .176
896#= ADU R SQUARE .5697 COEFF OF VARIABILITY 19.3PCT
897#=
8988= VARIABLE
                                    F
                  B
                                          SIG.
                                                  BETA ELASTICITY
                         S.E. B
6996=
9888= TOCHMAX
                  1.276
                            .529
                                   5.812 .#95
                                                   .92651 6.53679
                                                  .32665 .25972
-.35468 -.15961
9616= PROTO
                  .211
                           .157
                                    1.596 .296
9929= MAXMACH
                 - .558
                           .635
                                   .773 .444
9030= NZULT
                 1.661
                           1.478
                                    .458 .547
                                                  .19651 1.11463
9848= CONSTANT -14,214
                          6.431
                                    4.885 .114
9856=11WITIAL REGRESSION
                                          $1/15/82 18.25.57. PAGE 24
9868=
9878= FILE - NOMAME (CREATED - $1/15/82)
94842
9898= * * * * * * * * * * HULTIPLE REGRESSION * * * * * * * *
9186=
9118= DEP. VAR... ENG
                         ENGINEERING HOURS
9:26=
9138: VARIABLE(S) ENTERED ON STEF 5
9146= THTAREA TOTAL WETTED AREA
9156=
9166= MULTIPLE R
                  .9682 ANGVA
                                   DF SUM SQUARES MEAN SQ.
9178= R SQUARE
                                   5.
                                          2.205
                                                            1.683
                  .8248 RECRESSION
                                                    .441
                  .4839 RESIDUAL
                                                       .234 SIG. .382
9188: STR BEV
                                    2.
                                             .448
9198= ABJ R SQUARE .3868 COEFF OF VARIABILITY 23.8PCT
9266=
                                                  BETA ELASTICITY
9218= VARIABLE
                  8
                         S.E. B
                                    F
                                        SIC.
9228=
9236: TOCHMAX
                 1.466
                            .747
                                   3.546 .281
                                                  1.82841 7.19928
9248= PROTO
                 .251
                           .202
                                    .985 .426
                                                  .31038
                                                          .24679
9258: MAXMACH
                  -.662
                           .823
                                     .648 .585
                                                  -.42857
                                                         -.18857
                 1.066
9266= NZULT
                          1.776
                                    .360 .689
                                                   .26291 1.18718
                                                .11425 .92257
                  .252
9278: TUTAREA
                           .776
                                    .105 .776
9288: CONSTANT
                -17.614
                         12.988
                                   1.839 .358
9298=
```

```
9318= ALL VARIABLES ARE IN THE EQUATION.
    9336=
    9346=
    9350= COEFFICIENTS AND CONFIDENCE INTERVALS.
    9344#
                                   95 PCT 1.1.
    9370= VARIABLE
    9386:
                       1.4856
                                            4.6282
    9396= TOCHMAX
                                  -1,8696
    9486= PRCTO
                       . 2566
                                  -.6696
                                            1.6782
    9418: HANNACH
                       -.6628
                                  -4.2619
                                            2.8778
    9426= NZULT
                       1.8656
                                  -6.5753
                                            8.7666
                                           3.5962
    9436= THTAREA
                        .2518
                                  -3.6865
    9446= CONSTANT
                     -17.6144
                                -73,4972 38,2684
    9456=
    9444=
    9478: VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.
    9486=
    9498=
    9566= NZUL"
                      3.15364
    9518= MAXMACH
                      -.53997
                                .67484
    9526: THTAREA
                       .:5368
                               -.24795
                                          .60199
    9538= TOCHMAK
                       .11485
                               -.46378
                                          .30922
                                                    .55817
    9545= PRCTO
                       .66539
                                .86872
                                         -.62513
                                                  -.#368#
                                                             .64885
    9556=
                     NZULT
                               MAXMACH TUTAREA TOGUMAX PROTO
    9548=
    9574=
    9584=
                                                 61/15/82 18.25.57. PAGE 25
    9596=11NITIAL REGRESSION
    9618= FILE - NONAME (CREATED - 81/15/82)
    9638= 4 4 4 4 4 4 4 4 4 8 8 L TIPLE REGRESSID N + + + + + + + + + + +
    9648=
    9658= BEP. VAR... ENG
                               ENGINEERING HOURS
    966#=
    9476=
    9686= SUMMARY TABLE.
    9698:
                               F MULT-R R-SQ CHANGE R OVERALL F SIG.
    9790= STEP VARIABLE E/R
    9716=
    9728=
              TOCHMAX E
                              11.853 .815 .664 .664 .815
    9736:
            2 PROTO
                              1.965 .871 .759 .895 .525
                                                               7.862 .929
    9748=
          3 MARMACH
                                .540 .887 .787 .029 .502
                                                               4,939
                                                                     .978
    9756= 4 NZULT
                                .458 .983 .816 .828 .353
                                                               3.317 .176
    9760: 5 THTAREA E
                                .105 .908 .625 .609 -.263
                                                               1.865 .382
    9770=1141TIAL REGRESSION
                                                  81/15/82 18.25.57.
    9788=
    9796= FILE - NONAME (CREATED - $1/15/82)
    9818= + + + + + + + + HULTIPLE REGRESSION + + + + + + + +
    9828=
1
     9830=
    9848= RESIDUAL PLOT.
    9956:
                                                        4.8
                                                                          +250
    9944
            T VALUE
                     Y EST. RESIDUAL -2SD
    9876=
    1886=
             2.135
                       1.836
     9896:
              1.664
                       1.64:
                                 -.056
              2.754
    9966:
                       2.516
                                  .237
     9916=
              1.813
                       2.217
                                 -,484
                                 -.353
     9928=
              1.953
                       2.366
     1138=
              2.229
                       2.173
                                  .847
     9948:
              1.917
                       1.789
                                  ,128
     9956=
                       2.949
              3.645
                                  .896
```

```
4968=
 9978: NOTE - (+) INDICATES ESTIMATE CALCULATED WITH MEARS SUSSTITUTED
 9988=
              R INDICATES POINT OUT OF RANGE OF PLOT
 999#=
 66:8= NUMBER OF CASES PLOTTED
 9020: NUMBER OF 2 S.D. OUTLIERS
                                         # GR
                                                   # PERCENT OF THE TOTAL
 6636=
 8848= VON REUMANN RATIO 1,94889
                                              DURBIN-MATSON TEST 1.78528
 6656=
 #868= NUMBER OF POSITIVE RESIDUALS
                                          5.
 6676= NUMBER OF NEGATIVE RESIDUALS
                                          3.
 6080= MUMBER OF RUNS OF SIGNS
                                          5.
 6696=
 9186= NORMAL APPROXIMATION TO SIGN DISTRIBUTION IMPOSSIBLE.
 #118: USE A TABLE FOR EXPECTED VALUES.
#12#=11NITIAL REGRESSION
                                                  #1/15/81 18.25.57. PAGE 27
6:30=
8:48=
#15#= CPU TIME REQUIRED..
                                .3890 SECONDS
#16#z
8176=
#18#=
#19#= TOTAL CPU TIME USED...
                                .4778 SECONDS
8286=
8218=
6226:
8236=
9240= RUN COMPLETED
$258±
0260= NUMBER OF CONTROL CARDS READ 39
6270= NUMBER OF ERRORS DETECTED 0
$28$=$
8298=+EOR
MAND- LOCOUT
      5.484 SEC.
                        4.469 ADJ.
      14.854 SEC.
                         4.396 ADJ.
                         9.611
NMECT TIME & HRS. 38 MIN.
1/15/82 LOGGED OUT AT 18.54.14.
```

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()

APPENDIX F
REGRESSION REG 4

```
BUTH PROGRAM TALL NAME IN DET
 44: 888 PETRIERES
......
 ...
            . ti = .
      ::0=:
      :28=
                                                                                                                                                                                                          F1 (F F1 (4), F1 (5) F4 F ( )
                                                               VICELDADA DINAS DE LEGATES
NUMBERSES ANNASSES
      . .
      142:
      :::::
      ::!
                                                               E P E E P P STATUSTINA, RADNAUS FOR THE BODDA, EDTSWEE
     .\,\mathbb{R}^{\mathfrak{s}}
                                                                APPENDING OF THE LOTTE
          . 3 :
      100:
     1.2:
| CORP | CONTINUE CON
       110-
     313:
116:
140:
                                                                                      HANTA FRANCISCO
TODO TODO ENDO
HANTO MANUFACTURENO HELPE
      :5¢:
      168: INFLO FORMS - PRESPOSED
  168- 10-7 FGP-4
178- NOTH 1868-
168- SCH-178
                                                                                        Adams.
                                                                                       ENG: A .ENG:
                                                                                       000914 0001
7001914 0001
804847814 80484
                                                                                       #44F±_3:#44F
                                                                                        TmTARE4=LN(TmT4RE4)
                                                                                         NZ.LT=LN.NZULT)
    458= CORPLIE
                                                                                         MAXMACHILL (MAXMACH
   468= 30MF. TE
478= COMPUTE
                                                                                         TOGERAXEUN (TOGERAX)
                                                                                         MXAZ=MAXMAZ-+AZ__T
   488: COMPLIE
498: COMPLIE
                                                                                         TT=TOGWP4X+TWTAREA
                                                                                        PROTO-LNIFRCTO:
VARIABLES-ENGITULLYANFIMANHATICOCHMXMZITTIPRCTO
     500: REGRESSION
                                                                                           THTAREA, MAXPACH, NZULT, TOGHHAX
    5:2:
     528:
                                                                                         REGRESSION-DDS WITH MANS, TERRETS, TOGGRAA, TWTARES
     50#=
                                                                                         MAXMADHINZULT(1) /RESIDER
      543=
                                                                                         REGRESSION=TOOL WETH MINZYTT+PROTO, TOGWYAX, TWT4REA
      553=
                                                                                         MARKACHINZULT . 11 /RESIDER
     5+3=
                                                                                         REGRESSION MANY WITH MINZ, TT, PROTO, TOOMMAX, THTARZA
     578=
                                                                                          MAXMACH-NZULT:13/RESID=8
      588:
                                                                                         REGRESSION-MANHAT WITH MENZ, TT, PROTO, TOGUNAR, TWTGRES
      134:
                                                                                         MAXMACH.NZULT(1) /RESID=0
                                                                                        REGRESSIONEENG WITH MINZ, TT, PRITE, TOOWNAY, THTAREA
     444:
     6:2:
                                                                                         MAXMACHIAZULT(1)/RESID=6
    ..........
                                                                                       3
```

```
100 TENED (NAUT SATA
 . . . z
 ATRE GREETING OF NEEDED FOR REGRESSION
 , j =
c 73=
6884
1984 ENC OF FILE ON FILE F45
700= AFTER READING E LASEE FROM SLEFTLE NOVAME
718=LINITIAL REGRESSION 80745
                                                   #1715/02 14./FUSS/ F-03 C
 726=
 778: FILE - NOMAPE - CREATED - 01 NE/82
 746=
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1250:11NITIAL REGRESSION
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11581
JOTA: FOLE - NGNAPE - (CREATED - 0./15/62)
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1788: 189, 149,... (11)
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1798= ADJ R EILARE .8180 COEFF OF VARIABILITY
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:860= CONSTANT
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: 37#=
:38#=
1998: F-LEVEL OR TOLERANCE-LEVEL INSUFFICIENT FOR FURTHER COMPUTATION.
: 786=
:1.4:
:::3:
LASE: DISESTICIENTS AND CONFIDENCE INTERVALS.
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     2072:
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      1176: STE DEV
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  3760: IGEFFICIENTS AND CONFIDENCE INTERVALS.
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  3788= VAR:48_E
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     4600=.CNTTTAL REGRESSION
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     4020: FILE - NONAME - LIREATED - BOXES, BIT
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    4460: NUMBER OF NEGATIVE RESIDUALS
4490: NUMBER OF RUNS OF SIGNS
     4544:
    4510: NORMAL APPROXIMATION TO SIGN DISTRIBUTION IMPOSSIBLE. 4520: USE A TABLE FOR EXPECTED VALUES.
     4530+11NITIAL REGRESSION
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    454# =
    4558= FILE - NGNAME (CREATEL - $1/15/62)
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    4570= + + + + + + + + + + HULTIPLE REDRESSION + + + + + + + +
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5148= 33MST4NT
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5156:
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5210: FROTO NUMBER OF FROTOTYPE AIRCRAFT
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 5520: THTAREA
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 5830= MA1MAC-
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 584## MZGLT
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 5686:
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 5878=::N:T14L REGRESSION
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   : 114:
   SEASE VIN NEUMANN RATIO - ELEGEST
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   6460% AGRMAL APPROXIMATION TO SIGN DISTRIBUTION IMPOSSIBLE.
   64:0: USE A THELE FOR EXPECTED VALUES.
   6420×10NITIAL REGRESSION
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643#z
   64484 FILE - NONAME (CREATED - 81/15/82)
   645#=
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   6480° DEP. MAR... MARKET MANUFACTURING MATERIALS
   6478=
   4588: 454N RESPONSE
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                                                                                   STD. DEV.
   45:22
   6528= V4F14ELE(8) ENTERED ON STEP 1
   6536: TOGHMAX MAXIMUM TAKEOFF GROSS WEIGHT
   4542=
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7328= V46142LERS ENTERED DV 81EF - E
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 134#=
738## MULTIPLE R 1450 ANIVA OF SUMBILATED MEAN ED. F
738## R SILANE UNTIL REPRESENTE S. 1.07 (4.64)
757## STO DEM 1.079 RESIDAL D. 1897 (4.64)
758## AUD F SILANE 1450 108FF OF VANIMENTY FLORIT
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7420= V4F141LE
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75c6= 94R[48]E
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11.3= 113,441
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7738= NZULT
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775#=
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7780=.DNOTDAL REDRESSION
                                                    #1-15.62 .4.19.88. FAGE 28
7793:
  7888= FILE - NGNAME | COREATED - #1015/621
78 8:
 7:02:
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              7986= FILE - NONAME | COREMTED - $1915 61
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SINZE USE A TABLE FOR EMPECTED VALUES.
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             8328=
            1.78 F. 11 - N. North | FEATER - 21 (5/51)
            1112:
             2::2:
            6078= CEF. VAR... ENG. ENGINEERING HOURS
            838#≥
            8398= MEAN RESPONSE 2.185.6
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            8466=
* D 8418= VARIABLE(S) ENTEREL DA STER (1
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           8436=
          644## MULTIPLE R
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                                                                                                               $16.
            :500 =
            9510: TOGaffél
                                                      1.122
                                                                                .526 11.853 .414
                                                                                                                                         .81461 5.74671
                                                     -; 037
            ESSE: CONSTANT
                                                                             3.518
                                                                                                 E.875 .829
            £522:
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 :573:
RESAM MARIMELE EL ENTERED IN STEM LESSES AGRICANT.

RESAM FROTO LA NUMBER DE PROTOTRES AGRICANT.
 : : 10:
3. 5es
 Scod= VARIABLE
                                                                                F :::.
                                         i i.i. i
                                                                                                                EFF ELHITETY
£676=
8668= Tüüm#AI
                                       . 798
                                                            . 3
                                                                           15.765 .715
8698= ROTU .227
6788= CONSTANT -9.189
67.8=:INCTIAL REURESSIT
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Tuest .213
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areas fole - Novare - Coreater - at 15,50
 :76£=
 67764 DEF. WARLIN ENG.
                                                ENGINEERING HOUSE
: 35
6798: VARIHELERE ENTERED DA GTEF D
6688: MARMADH MARIMUM MACH AUMEER
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                                                                            FF EN ELARED NEW ILL FILL FOR LIFE AND A PER LIFE A
 AVOVA 4738. - F BLF17LL* =5188
3658: ADD R 300485 (6288 00387 (R V481450075)
 - 5182
8878: VANCASES
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:666
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178: -1171
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-JAPIAP =8163
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EFORE CONSTANT
: i : i : i
   29482
2953=
EFRB: VARIABLE EN ENTERED CA STER 4
REPRES NOUT LITERATE LOAD FACTOR
9868:
9818= MILTOPLE A
9218= R SQL4RE
                                    .4831 ANDVA DF SUM SQUARE: MEAN 32. F
.8156 FEGRESSION A. L.168 .545 .1317
.4851 RESIDUAL 3. ,443 .164 810. .176
1838 - STO DEV .4853 RESIDUAL S. .443
PORT STILLTR OF TRANSPORT SEARCE R SEARCE R 443
9458=
9868= VAR:AB_E
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9888= TOCHTAI
                                      1.175
                                                             .519
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.31665 .25972
-.35468 -.15982
9898= PROTE
                                      .1::
-.55ō
                                                                              1.596 .296
.773 .444
.458 .547
                                                            .167
9188= 9AXNAC-
                                                            .635
9118= NZ)_*
                                     :.66:
                                                                                                               .19851 1.11463
                                                           1.478
9.28= CONSTANT
                                 -14,114
                                                          2.431
                                                                              4.885 .114
PISS=11NITIAL REGRESSION
                                                                                            #1/15/52 14.19.50. PAGE 24
9:46:
9.50% FILE - NONAPE (CREATED - 01 15/61)
9178= DEF. VAR... ENG
                                                        ENGINEERING -DURS
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ROLLAR MARCHAELERS ENTEFEL ON FTEF . 5
FOLGAR TWITAKER . TOTAL WETTER FFER
 THE STATE OF                                                                                                                                     1574 EL4377
 9290: .4914812
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 1577:
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 9322= FROTT
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934#= AZJLT
935#= TaT-RE-
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 9368= 13N2T4NT
  n syk skulkel og nolekkkeletuevel oktyskolekt for forfæst lokfolktor o
 : . . . . . . .
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  4525 V48148LE
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 10 24 TIN 41 F
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-4,27,7
-6,3753
-1,41,3
-73,475
                                                ....
 fulfås #4;*=[-
                                               1.6:12
 95224 NZLIT
95224 NZLIT
95224 NZLIT
                                          ..8:5.
.25.1
-.1.:4
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FELEF
 1948:
 SEPRE VARIOANDE COVARILA DE PATRON DE CANDEMANDEZ REGRESEDON DETECNOENTO
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  76:
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 17722 Tuefel
                                                                       .::::
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-.14705 .e766*
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  96.8= *13*4(-
                                               . 835
 1.28: VI...
                                                                      ...484
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  0,39=
                                           27.77
                                                              TOTATAN TATARES MANAGE NECLT
  ....
  -558=
  -- 68=
                                                                                                                #. 15/82 (4):3/38/ P40E 25
  PATRICULTURE PROPERTIES.
   ....
  9698= FILE - NORAPE - (DREATED - - $1/15/81).
  - 123:
  9720=
  973## BEF. VAR... ENG
                                                                    ENGINEERING HOLRS
  174#=
  975#=
 9768: 30984R* TAELE.
 77g=
  P752= ETEP VARIABLE E/R
                                                                   F MULTIN RIES CHANGE IN CHERALS F 300.
  7794:
                                                                11.851 .815 .554 .554 .515
1.763 .671 .755 .875 .525
.548 .887 .757 .827 .561
.456 .486 .556 .826 .155
                                                                                                                                              11.653 .614
7.351 .215
  : : :
                          TIGH#AN E
  19.84 2 PROTO
                                                                                                                1528: 3 MATMAC- E
  9632= 4 NZULT
  FRANCE S THTAREA E
FRENCHICATIAL REGRESSION
                                                                     191.- 986. 315, 399, 381.
   11.35
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SERVE FUEL STRAKE CORESTED SCRIPT EL
     1556
     SERTER BREEF BREEF CONTRACTOR SECTIONS SERVICES
     100
    17,61
     $40.4 $E(D)40 $UTV
    4.5
               V42.5 1 EST. RESIDUAL -250
     . .
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    *;**
     63692
               1 :::
                          ....
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                         1.7.5
    11732
               -.é55
    33532
               395g=
                                      494
    1112:
                                     ٠,:٠:
                                      . 2.4
     40:3:
    2412:
    1313:
    ) • · ·
    ATHER NOTE - IA CONTINUES SETTMATE CALCULATED ACTA MEMOR LICENCINCES 

$488 - - FORCEMENT CONTINUES CALCULATED ACTA MEMOR LICENCINCES
    4276:
    1276 :
    PARRY NOMER OF TREET RUTTED SUB-
FLARE NOMER OF DISTRIBUTED SUB-
FLARE NOMER OF DISTRIBUTERS SUB-FLARE PROPERTY.
    2 12:
    1994-10 (1744 AAN) 10 (1949-19)
                                                 1
    $1467 KUTDER OF FOEDTIVE RESOURCE
KUTGE NUMBER OF NEGATIVE RESIDIACE
KUNGE KUTBER OF FUNE OF SIGNE
    è: è:
   G. 184 VIRKO, APRADADMATON TO BODY DOSTOBUTO NI DHF18,1028.
W. 487 188 A TABLE FOR BARBOTED VALUES.
    ALEBRITATIAL REGRESSION
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    ....
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    £ .... =
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     RATE TOTAL OF A TOME LEED AND ARRANGED NEED NOT
    715gz
    7217
    1:00:
    3:.6=
    ALDER TO DEFERE
    t . . d:
    #146# NUMBER OF CONTROL CHARGE FEAL (4)
#158# NUMBER OF ERRORE DETECTED (4)
    # 1: # = :
    #37#=+EJR
..GET-FR44-10-8020

D LE MAME FA4 HAS SEEN RETRIEVED

...REWING/8995/REDZI-F44
    ..SPSS:D=FA4:]=RED2:LO=AERV:L=W2:NR
L=BFSE
LE=WLOTA EXCECEC
    ..AETURYMIATAS
..IIIT males
```



APPENDIX G
FACTOR ANALYSIS INITIAL

```
VERSION SUB- STUNE USE 1779
      133:
       ...
       266:
       2:8=
      226=
      238: RUN NAME
                          FACTOR ANALYSIS
      240: VARIABLE LIST FTHT. FNZU. FREM. FTOG. ATHT. ANZU
ſ,
      25#=
                           ANXH-ATBG-CTHT-CNZU-CHXH-CTGG
      268=
                           FF.AA.CC.FN.AN.CN.FN.NR.CH
      276= INPUT FORMAT
                          FREEFIELD
(
      286= INPUT HEDIUM
                          BISK
      Z98= N OF CASES
                          UNKNOWN
                          FF=FTMT/FTBC
      366= COMPUTE
0
      310 = COMPUTE
                          AA=ATHT/ATOC
                          CC=CTWT/CTOC
      329= COMPUTE
      336= COMPUTE
                          FM=FMZU#FTWT
                          AN=ANZUSATUT
      348= COMPUTE
      350= COMPUTE
                          CN=CNZU+CTHT
      360= COMPUTE
                          FH=FNZU/FNKS
      370= COMPUTE
                           RP=ANZU/ANXP
      386= COMPUTE
                          CH=CNZU/CNXM
                          VARIABLES= FTHT TO CTOC/TYPE=PA1/
      398= FACTOR
                          ROTATE=QUARTIMAX/
      44E:
(
                          VARIABLES=FN.AN.CN/TYPE=PA1/
      416=
                          ROTATE=QUARTIMAX/
      426=
                          VARIABLES=FF.AA.CC/TYPE=PAI/
      43#=
      444:
                          ROTATE=QUART: MAX/
      454=
                          VARIABLES=FM.NM.CM/TYPE=PA1/
                          ROTATE=QUARTIMAX/
      468=
      478:
                          VARIABLES=FN.AN.CN.FM.NM.CM/TYPE=PAI/
                          ROTATE=QUARTIMAX/
      468:
      498= OFTION
      500= STATISTICS
      51#= READ INPUT DATA
      52#=
      53#= ###537## CM NEEDED FOR FACTOR
      544=
      550= END OF FILE ON FILE DAZ
       568= AFTER READING
                              & CASES FROM SUBFILE MONAME
                                                     #3/22/82 14.42.31. PAGE 1
      570=1FACTOR AMALYSIS
       58#=
      598= FILE - NOMAME (CREATED - #3/22/82)
      688=
      616=
      628= VARIABLE
                                       STANDARD DEV
                                                        CASES
                               MEAN
      636=
                                           558.4917
      648= FTHT
                         2347.6667
      656= FNZU
                                             1.2813
                           18.6667
                                               .7898
      668= FMXM
                            1.8756
                         43292.9066
      678= FTGC
                                          17918.5191
       690= ATUT
                         2354.3333
                                           932.5985
      698= MIZU
                            7.3866
                                             3.9981
      766= ARIM
                            1.6366
                                               .4283
      710= ATOC
                         49742.8666
                                         26188.5157
      729- CTUT
                         14431.6667
                                         16272.9988
                                              .3387
      738= CMZU
                            3.6756
      746= CHIM
                              .6958
                                               .1887
      750= CTOC
                       494656.5666
                                        433179.6386
C
                                                     83/22/82 14.42.32.
      768=1FACTOR AMALYSIS
                                                                           PAGE 3
      776±
      780: FILE - NOMANE (CREATED - $3/22/82)
(
      798=
      866:
      816= CORRELATION COEFFICIENTS..
(
      826=
      836:
```

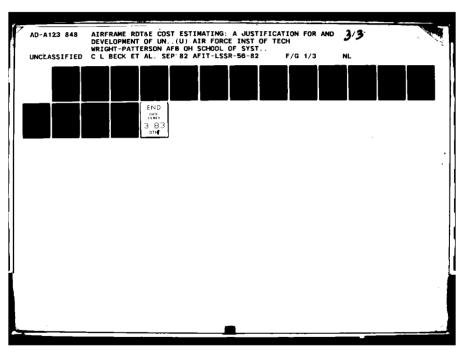
```
644:
       852=
       866=
                            FTUT
                                        FNZU
                                                     FRIE
                                                                 FTOC
                                                                              4","
       676=
       88#= F"#"
                            1.66000
                                        -.14619
                                                                  .42766
                                                                               .37589
                                                      .68111
       896= FNZU
                            -.:4419
                                        1.60666
                                                      .52831
                                                                  .21159
                                                                               .62365
       966: FHYN
                                          .58831
                             .68111
                                                     1.55666
                                                                  .75629
                                                                               .38615
1
       91#= FTGG
                             .42768
                                          .21159
                                                      .75629
                                                                 1.06668
                                                                               ,19018
       924= ATHT
                             . 37589
                                          .62369
                                                      . 38819
                                                                  .29928
                                                                              :.00000
       938= ANZU
                             .85247
                                          .13969
                                                      .56814
                                                                  .62256
                                                                               .18014
C
                             .14585
       948= ANXH
                                          .#5571
                                                     -.63891
                                                                 -.616:6
                                                                               .3300:
       956= ATOC
                             .65877
                                          .61835
                                                      .46376
                                                                  .27758
                                                                               .9:536
                                                                  .25724
       968= CTUT
                             .46542
                                         .76612
                                                      .65949
                                                                               .59414
0
       978= CNZU
                             .72298
                                        -.24192
                                                     -.36498
                                                                  .18455
                                                                               .2449:
       986= CHXM
                            -.58684
                                         .76536
                                                     .65162
                                                                  .29588
                                                                              .3289:
       996= CTOG
                            -.24649
                                        -.19169
                                                                 -.37241
                                                                              -.35672
                                                     -.26186
      1666=
      1616=
      1829=
      1636=
                            ANZU
                                                                 CTMT
      1646:
                                                     ATOC
                                                                             CNIL
                                        HIMA
      :#54=
      :868= FTW
                             .05247
                                         .14585
                                                      .65877
                                                                  .88542
                                                                              .72295
      1876= FNZU
                             .13969
                                         .6557:
                                                      .6:635
                                                                  .76612
                                                                             -.24192
      1885= FHXH
                             .56814
                                        -.63691
                                                      .46378
                                                                  .65949
                                                                             -.36498
      1898= FTGC
                             .62256
                                        -.61616
                                                      .37758
                                                                  .25724
                                                                              .:8455
      1166= ATHT
                             .18314
                                         .338#1
                                                      .91539
                                                                  .594;4
                                                                              .2449]
      1118= ANZU
                            1.60000
                                                                 -.19588
                                                                             -.46842
                                        -.23061
                                                      .26372
                                                                              .22547
      1128= AMXM
                            - .236&1
                                        1.66668
                                                      .23536
                                                                 -.28186
      1138= ATOC
                            .28372
                                         .33536
                                                     1.86666
                                                                  .51375
                            -.1958€
                                        -.281€₺
                                                      .51375
                                                                             -.66758
      1146= CTHT
                                                                 -. 48842
                                                                             :.66868
      1150= 2NZU
                                         .22547
                                                      .3:942
                                                                 -. 8875E
                             .29592
      116#= CHXM
                                        -.48998
                                                      .84633
                                                                  .53421
                                                                             -.58445
      1176= CTOG
                            -.85836
                                        -.28459
                                                     -.46924
                                                                  .28519
                                                                              .262€:
      1186=
      1196=
      1200=
      12:6=
                                        CTGG
      :229=
                           CHXH
      1236=
      1246= FTWT
                            -.58684
                                        -.24#49
      1258= FNZU
                            .7653&
                                        -.19169
      1260= FMXM
                             .65162
                                        -.26186
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      1276= FTOG
                             .29868
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      1286= ATHT
                                        -.35672
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C
                            -.48998
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      1366= ANXN
      1316= ATOC
                             .#4633
                                        -.46924
      1326= CTWT
                             .53421
                                         .28519
      1336= CNZU
                            -.58445
                                         .26281
      1346= CHXM
                            1,95550
                                        - . 65286
      1350-1FACTOR AMALTSIS
                                                       #3/22/82 14.42.32.
                                                                               PACE
      1346=
      1376= FILE - NOMAME (CREATED - #3/22/82)
     1300=
1396=
1400=
0
      1416=
C
                           CHER
     1426=
                                        CTOC
      1436:
      1446= CTOC
                           -.65296
                                        1.60000
C
      1458-1FACTOR AMALYSIS
                                                       63/22/82 14.42.32.
                                                                              PAGE
      1466=
      1478: FILE - NOMAME (CREATED - $3/22/82)
Ç
     1498=
```

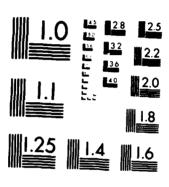
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1566=
      15:#=
      1528= VARIABLE EST COMMUNALITY FACTOR EIGENVALUE FOT COM FOT
      1536=
                                               4.52772 37.7
      1548= FTHT
                          1.00000
      1550= FNZU
                          1.05566
                                                3.83168 25.3
                                                                53.8
      1560= FHIP
                          1.65006
                                                2.25841 18.8
                                                                 81.8
      1576= FT0G
                          1.66666
                                                1.66523
                                                                96.9
      1586= ATUT
                          1.66666
                                                 .37764
                                                               :60.6
      1596= ANZU
                          1.56568
                                                 . 85666
                                                               166.6
      1666= AMXH
                          1.65506
                                                 . 88666
                                                               188.8
      1616= ATGC
                          1.95566
                                                 . 66566
                                                               160.8
                          1.50005
      1426= CTUT
                                                 .55666
                                                               156.8
                                                          . 8
                          1.89668
      1630= CNZU
                                                -.96666 -.6
                                        15
                                                              166.6
                          1.00000
      1648= CMXH
                                                - . 30402
                                                         - .1
                                                               :60.0
      1456= CTOC
                          1.65666
                                                - . 26666
                                                        -.1
                                                               :00.6
      1660=1FACTOR ANALYSIS
                                                     83/22/82 14.42.32.
                                                                            PAGE
      1678=
      1680= FILE - NONAME (CREATED - 63/22/82)
      1698=
      1766=
      1718= FACTOR MATRIX USING PRINCIPAL FACTOR, NG ITERATIONS
      1720=
      1736=
      1748=
      175#=
      176#=
                          FACTOR 1 FACTOR 2 FACTOR 3 FACTOR 4
      :77#=
      1786= FTUT
                            .16692
                                        .83731
                                                   -.28623
                                                               .48383
      1796: FNZU
                            .82744
                                       -.88645
                                                   .45135
                                                              -.32454
      1866: FHXH
                                                               .28756
                            .68835
                                       -.26696
                                                   -.#6731
      1816: FT0C
                            .68555
                                        .88949
                                                   - .44449
                                                               .53196
                                                   .26323
      1828: ATHT
                            .74331
                                        .54622
                                                              - .24983
      1836= ANZU
                            .53246
                                       -,23288
                                                   -.79585
                                                              ~.17350
      1848: ANXH
                           -.26693
                                        .61125
                                                    .#9363
                                                              -.73898
      185#= ATOC
                            .69767
                                        .69563
                                                    .#3449
                                                              -.12273
      1860= CTUT
                            .6836
                                        .62381
                                                   .6463#
                                                               .24130
      1870= CNZU
                           -.21668
                                       .86625
                                                   .13666
                                                               .44396
      188#= CHXM
                           .67383
                                       -.68885
                                                   .29659
                                                              -.16165
      189#= CTOC
                           -.44141
                                       -.18368
                                                   .73188
                                                               .48554
      1966:
      1916=
      1928:
      1948: VARIABLE
                        COMMUNALITY
      1956=
      1965= FTHT
                           .97332
      1978: FNZU
                           . 99374
      1986: FHIM
                           .96299
     1996= FT0G
                           .95947
      2505= ATNT
                           .976#5
     2818- MIZU
                           .99997
     2620= ARXH
                           .99962
     2836= ATOC
                           .98485
     ZS46= CTVT
                           .94396
     2656= CNZU
                           .98265
     2848= CHXH
                           .93434
     2676= CTOC
                           .99998
     2000=1FACTOR ANALYSIS
                                                     #3/22/82 14.42.32. PAGE 7
     26962
     2188= FILE - NOMANE (CREATES - 83/22/82)
O
     2116=
     2128=
     Z136=
             QUARTIMAL ROTATED FACTOR MATRIX
     2140= AFTER ROTATION WITH KAISER NORMALIZATION
```

```
2162=
      2176=
      2186=
                          FACTOR 1 FACTOR 2 FACTOR 3 FACTOR 4
      2198=
      2266=
      2218: FTWT
                                                               .18324
.84711
                                        .94929
                                                    .11259
      2226= FNZU
                            .94518
                                       -.39935
                                                    .84962
      2236= FHXM
                            .52783
                                       -.17676
                                                    .76819
                                                                .25166
      2246= FT0G
                            .23366
                                        .27668
                                                    .81393
                                                                .39679
      2256= ATHT
                            .93478
                                        .24226
                                                   -.11673
                                                                .17696
      2260= ANZU
                            18158.
                                       -.17645
                                                   .37197
                                                                .91265
      2276= AHXH
                                        .20212
                            .16827
                                                   -.94996
                                                                .16729
      2286= ATOG
                            .86927
                                        .4B26#
                                                   -.65668
                                                                .34939
      2296= CTUT
                                       -.8542£
                                                    .36210
                                                               -.39767
                            .88712
      2366= CNZU
                                       .88575
                                                   -.18731
                                                               -.32512
                            .#2968
                                       -.7:349
      2316= CHXM
                            .53389
                                                    .37328
                                                               .62475
                                                               -.97999
      2328= CTOC
                                       -. $4591
                           -.17313
                                                    .98667
      2336=
      2348=
      235#=
      2368=
      2376= TRANSFORMATION MATRIX
(
      2386=
      239#=
      2468=
      2418=
                          FACTOR 1 FACTOR 2 FACTOR 3 FACTOR 4
      2428=
      2436=
                                       -.08452
      2448= FACTGR 1
                                                    .46793
                                                                .35345
                            .86559
      2458: FACTOR 2
                            .29493
                                       .8675#
                                                   -.39612
                                                                .65965
      246#= FACTOR 3
                            .46641
                                       -.19452
                                                   -.28494
                                                              -.83823
      2470= FACTOR 4
                                        ,44997
                                                    .76297
                                                              -.4189£
      2480=1FACTOR ANALYSIS
                                                     63/22/82 14.42.32.
                                                                            FACE
      2588= FILE - NONAME (CREATED - #3/22/82)
      2516=
      2528=
      2538= FACTOR SCORE COEFFICIENTS
      2544=
      2556=
      2564=
      257#=
      258#=
                         FACTOR 1 FACTOR 2 FACTOR 3 FACTOR 4
      2596=
•
      2666= FT47
                                        ,36159
                                                                .64309
                            . 96396
                                                   .19416
                                       - 13786
      2618= FMZU
                                                  -.69177
                                                               -. #2917
                            .27858
C
      2628= FMXM
                            .67751
                                      -.81981
                                                   .25961
                                                               .63619
      2636= FT0C
                                        .16878
                           -.53242
                                                    .33474
                                                                .8975&
      2646= ATUT
                            .26962
                                        .#5577
                                                  -.12324
                                                                .82782
0
      2650= AMZU
                           -.57138
                                       -. #5135
                                                   .#8428
                                                                .37157
      2668= MIXH
                            .11958
                                       -,#1235
                                                   -.42825
                                                                .12465
      2678= ATOC
                            .21348
                                       .15248
                                                   -.67385
                                                                .68324
      Z686= CTUT
                            .22859
                                       -. 86147
                                                   .11687
                                                              -.24698
      2696= CHZU
                                        .33195
                                                   .64837
                            .81448
                                                              -.15268
                            .14864
                                       -,25189
                                                    . #544#
                                                              -. 63642
      2700- CHEM
      2718= CTOC
                           -.66327
                                                   .11718
                                        .81367
                                                              -.42625
      2728=
      2738: ERROR MUMBER.. 843. PROCESSING CEASES, ERROR SCAN CONTINUES.
C
      2746=
      2750×
      2746- CPU TIME REQUIRED ...
                                    .1536 SECONDS
0
      2776=
      2790=
      2796=
1
      2866:
              --- ERROR SUMMARY
      2816=
```

APPENDIX H
FACTOR ANALYSIS

```
CARRESTA NAME
                     FACTOR ANALYSIS
 118: AR142LE LIST FTWT FREU-FREM FTOG ATWT (ANZU-
                    ARXM.ATOG.CTHT.CNZU.CRXR.CTOG.
 :14=
 :30:
                    FF.AA.CC.FN.AN.CN.FH.NH.CH
 148=INPUT FORMAT
                    FREEFIELD
 150=INPUT MEDIUM
160=N OF CASES
                    BISK
                    UNKROWA
 178=00MPUTE
                    FF=FTHT/FTOG
 168=COMPUTE
                    AA=ATUT/ATOG
                    CC=CTHT/CTOG
 199=COMPUTE
 200=COMPUTE
                    FN=FNZUeFTUT
 216=COMPUTE
                    AN-ANTHAATHT
 229=COMPUTE
                    CN=CNZU+STUT
 236=COMPUTE
                    FH=FNZU/FHIR
 246=COMPUTE
                    NH=ANZU/AHXE
 258=COMPUTE
                    CH=CNZU/CHIM
 Z71=FACTOR
                    VARIABLES=FF , AA . CC/TYPE=PA:
                    ROTATE=QUARTIMAX/
 296±
                    WARIABLES = FM. NH. CH/TYPE = PA1/
 386=
                    ROTATE=QUARTIMAX,
 310=
                    VARIABLES=FH:AN; CN:FH:NH:CH:TYFE=FA1
 32#=
                    ROTATE=GUARTIMAX/
 33#=
 34#=OPTIONS
 350=27AT157135
                    ALL
 368-READ INPUT DATA
.. SAVE FALINIO
..RETURN.
..REWIND, SPSS, DAZ, FA1
..SPSS.D=DA2.1=FA1.LO=ABRV.L=W1.NR
PSS ERRORS
..EDIT.W1.S
. 1A
   198=1
 116=5
                                                 #3/22/81 15.26.29. FAGE :
 126:
               VOGELEACH COMPUTING CENTER
 136:
 146 =
               NORTHWESTERN UNIVERSITY
 15#=
               3 P S S - - STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES
 160=
 17#=
               VERSION 9.8 -- JUNE 18, 1979
 184:
 196=
 266=
 210:
 226:
 236= RUN NAME
                     FACTOR ANALYSIS
 240= VARIABLE LIST FTWT.FMZU.FMXM.FTOG.ATMT.AMZU.
                     AMXM, ATOG . CTUT, CNZU, CNXH, CTOG.
 268=
                     FF.AA.CC.FN.AN.CN.FH.NN.CH
 278= IMPUT FORMAT
                     FREEFIELD
 200: IMPUT HEBIUM
                     BISK
 298= N OF CASES
                     TANK MORN
 366= COMPUTE
                     FF=FTNT/FTOG
 31#= COMPUTE
                     AA=ATHT/ATGC
 328= COMPUTE
                     CC=CTHT/CTOC
 336= COMPUTE
                     FN=FNZUOFTHT
 346= COMPUTE
                     AN-AMZUSATUT
 358= COMPUTE
                     CN=CNZU+CTNT
 36#= COMPUTE
                     FR=FNZU/FNIR
 376= COMPUTE
                     HH=ANZU/ANXH
 386= COMPUTE
                     CH-CNZU/CHXM
 398= FACTOR
                     VARIABLES=FF: MA: CC/TYPE=FA1/
                     ROTATE = QUARTIMAX/
 488:
```





MICROCOPY RESOLUTION TEST CHART NATIONAL BUREAU OF STANDARDS 1963 A

```
413=
                            VARIABLES-FH.NH.CH/TTPE+FA1/
  (
                             ROTATE = QUARTINAI/
         420=
                             WARIABLES-FN-AN-CN-FN-NN-CH/TYPE-PA1/
         436:
         448:
                            ROTATE : QUARTINAL!
         456: OPTIONS
         460 STATISTICS
                            ALL
         478= REAC IMPUT BATA
- C
         494-
         496= 86653166 CH MEEDED FOR FACTOR
  C
         516= END OF FILE ON FILE DAZ
         526- AFTER READING
                               & CASES FROM SUBFILE NONAME
         530=1FACTOR AMALTSIS
                                                      #3/22/82 15.26.29. PAGE 2
         SSG= FILE - NONAME (CREATED - $3/22/82)
         544:
  0
        579=
         586= VARIABLE
                                MEAN
                                        STANDARD DEV
        594=
  С.
         688= FF
                               .6597
                                                . 6268
         618= AA
                               .8485
                                                .6672
         628= CC
                               .6426
                                                . 6266
  C
        630=1FACTOR ANALYSIS
                                                      63/22/82 15.26.29.
                                                                            PACE
        648×
        658= FILE - NUMAME (CREATED - #3/22/82)
 C
        668=
        678=
        68#= CORRELATION COEFFICIENTS...
 (
        698=
        766=
        718=
        728=
        738=
                           FF
                                                   CC
        744:
 C
        756= FF
                                       -.#3852
                                                   -.12345
                                       1.00000
        768= AA
                            -.63852
                                                   -.49291
        776= CC
                            -.12345
                                       -.49291
                                                   1.50006
 C
        786=1FACTOR AMALTSIS
                                                      #3/22/82 15.26.29. PAGE 4
        796z
        986: FILE - NOMAME (CREATED - 83/22/82)
 C
        816=
        826=
        836=
 C
        846:
        858= VARIABLE EST CONNUMALITY FACTOR EIGENVALUE PCT CUM PCT
        844=
 C
        876= FF
                                                1.50032 56.0
                                                               54.6
        895= AA
                                               1.61867 33.9
                                                              83.9
        896: CC
                                                 .48161 16.1 186.8
 O
        900-IFACTOR AMALTSIS
                                                     83/22/62 15.24.29.
                                                                           PACE
        926- FILE - HOMANE (CREATER - 63/22/82)
       956- FACTOR MATRIX USING PRINCIPAL FACTOR, NO ITERATIONS
        16
        178:
 0
                                     FACTOR 2
       1616-
 0
      1020- FF
                            .14764
                                        .97714
       1836- MA
                            .84736
                                      -.24225
       1946- CC
                                      -.66748
                           -.87174
 C
      1656=
      1868:
```

```
:878=
      1888=
1898= VMRIABLE
1188=
                           COMPRIMALITY
       1116= FF
                              .97729
       1125= M
                              .77441
       1136: CC
                              .76449
       1146-1FACTOR AMALYSIS
                                                          83/22/82 15.26.29. PAGE 6
       1156-
      1166= FILE - NONAME (CREATEB - 63/22/82)
      1178=
      1180=
1190= QUARTIMAX ROTATED FACTOR MATRIX
1280= AFTER ROTATION WITH KAISER MORMALIZATION
0
      1216-
      1225-
      1230-
      1246=
      1256=
                            FACTOR 1 FACTOR 2
C
      1268=
      1276= FF
                               .63672
                                           .98816
      1286= AA
                              .87836
                                          -.13812
C
      1296= CC
                             -.85721
       1366=
      1310=
C
      1326=
      1336=
      1346= TRANSFORMATION MATRIX
C,
      1356=
       1360=
      1376=
C
      1386=
      1396=
                            FACTOR 1 FACTOR 2
      1446=
      1416= FACTOR 1
O
                              .99268
                                           .12981
      1428= FACTOR 2
                             -.12591
                                           .99248
      1436=1FACTOR AMALYSIS
                                                          63/22/62 15.26.29. PAGE 7
Ç
      1446=
       1450= FILE - NOMANE (CREATED - 83/22/82)
      1446=
C
      1476:
      1496: FACTOR SCORE COEFFICIENTS
      1496=
(
      1506=
      1516=
      1526=
C
      1536=
                            FACTOR 1 FACTOR 2
      1546=
                                          .96485
-.16798
      1550= FF
                             -.51679
0
      1568- MA
                              .50736
      1579- CC
1586-
                             -.56078
                                          -.13599
      1990- ENGOR MUNIER.. 043. PROCESSING CEASES: ERROR SCAN CONTINUES.
1400-
1410- --
1420- CPU TIME REQUIRED.. ,0000 SECONDS
0
      1630=
1640=
1650=
G
      1668=
      1470=
1400=
1490=
                 ---- ERROR SURMANT ----
(
      1700-
      1716-
                 ERROR MUNICER.. 843
                 WARTABLE NAME ON SUBSEQUENT WARTABLES LIST IS NOT
      1728:
```

```
366=OPTIONS
        316=STATISTICS
        328-READ IMPUT BATA
       .. SAVE . FAI . N.O
        SUCH PROGRAM CALL MANE - RM
       ..RETURN #1
       .. REWINF : SPSS . BAZ . FA1
       SUCH PROGRAM CALL MANE
                                - REVINE
       ..SPSS.D=DA2.1=FAA1.LO=ABRV.L=U1.NR
      1 9755
       ..EDIT:U1:S
      Lif
 0
         166=1
       116=$
       129=
                                                       #3/22/82 15.41.26. PAGE 1
       136=
                      VOCELBACK COMPUTING CENTER
                      NORTHWESTERN UNIVERSITY
       144:
       156=
                     S P S S - - STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES
       168:
       175=
        186=
                      VERSION 8.6 -- JUNE 18, 1979
        198=
       286=
       216=
       224:
       238= RUN NAME
                            FACTOR AMALYSIS
       248= VARIAGLE LIST FTWT.FMZU.FMXM.FTGG.ATWT.ANZU.
C
       25#=
                           AMENIATOGICTHT, CHZU, CHEN, CTOGI
       268=
                           FF.AA.CC.FN.AM.CN.FN.NH.CH
C
       276= IMPUT FORMAT
                           FREEFIELD
       288= INPUT MEDIUM
                           DISK
       298= N OF CASES
                            UNKNOWN
C
       386: COMPUTE
                           FF=FTHT/FTOC
                           AA=ATUT/ATOC
       318= COMPUTE
       320= COMPUTE
                           CC=CTNT/CTOG
C
       336= COMPUTE
                           FN=FNZU+FTNT
       346= COMPUTE
                            AN=ANZUSATUT
       356= COMPUTE
                           CN=CNZU+CTWT
C
       348= COMPUTE
                           FH=FNZU/FNXH
       376= COMPUTE
                           IMI=ANZU/ANXH
       386= COMPUTE
                           CH=CHZU/CHIM
C
       398= FACTOR
                           VARIABLES=FN.AM.CN.FN.NM.CN/TTPE=PA1/
ROTATE=GUARTIMAX/
       416= OPTIONS
O
       428: STATISTICS
                           ALL
       430- READ INPUT DATA
       458= 60053100 CM MEEDED FOR FACTOR
      470- EMB OF FILE ON FILE BAZ
400- AFTER REABING 6 CAS
                               6 CASES FROM SUBFILE MONAME
       498=1FACTOR AMALYSIS
                                                       63/22/82 15.41.26.
                                                                              PACE
0
      518= FILE - NOMARE (CREATES - 03/22/82)
       526=
       530+
C
       546- VARIABLE
                               REAM
                                        STANDARD DEV
                                                         CASES
       226-
       568: FN
                         24959.3756
                                           6162,7198
       578= AM
                         17507 . 1000
53014 , 4000
                                           9271.5710
       590: CN
                                          30946,1497
```

```
2.7336
7.1615
                                  4.5272
          598= FM
          666= KM
                                  8.4154
          616- CR
                                  5.7619
                                                    1.8517
          628=1FACTOR AMALYSIS
                                                             #3/22/82 15.41.Z6.
                                                                                     PACE
                                                                                            3
          648: FILE - NOMANE (CREATER - #3/22/82)
          656=
- C
          446*
          678= CORRELATION COEFFICIENTS ..
          690=
690=
700=
710=
  0
   0
          728=
738=
                                                                      FH
                                Fil
                                             AH
                                                          CN
                                            .43466
1.66666
          740- FN
                                1.00000
                                                           .51375
                                                                       -.21144
                                                                                     .86217
          758= AN
768= CN
   0
                                 .43646
                                                          -.03792
                                                                       -.45135
                                                                                     .77463
                                             -.83792
                                 .51375
                                                          1.66566
                                                                                    -.66382
                                -.21144
                                             -.45135
                                                          -.52386
                                                                       1.00000
                                                                                    -.76119
          778= FH
                                                          -.86382
                                                                       -.76119
                                                                                    1.00005
   C
          796= IM
                                 .86217
                                              .77463
                                             -.27868
                                                          -.39962
                                                                                    - .43399
                                                                        .56638
                                 .28844
          796= CH
          966=
   C
          818=
          826:
          836:
          844=
   C
                                CH
          856:
          866= FN
                                 .29644
   (
          878= AN
                                 -.27908
          886= CN
                                -.39982
          896= FM
                                 .54838
                                - .43399
          966× MI
          916= CH
                                1.00008
                                                                                     PAGE
                                                             63/22/82 15.41.26.
          926-LFACTOR AMALYSIS
   (
           936=
           948= FILE - NONAME (CREATED - #3/22/82)
           956=
   (
           968=
           976=
   C
           990: VARIABLE EST COMMUNALITY FACTOR EIGENVALUE PCT CUR PCT
          1666=
                                                       2.79553
                                                                         46.6
71.2
          1616: FN
   C
                                                       1.47425 24.6
          1828= AN
                                                       1.29498
                                                                         92.7
          1836= CN
                                               3
                                                                21.6
                                                                         99.8
          1848= FH
                                                        .37298
                                                                 6.2
   O
                                                                        196.6
          1656= WI
                                               5
                                                         .56225
                                                                 1.6
          1646= CH
                                                                        100.0
                                                             #3/22/82 15.41.24.
                                                                                      PACE
                                                                                             5
          1878-1FACTOR ANALYSIS
   0
         1908=
LOTS= FILE - NOMANE (CREATED - $3/22/82)
          1180-
         1128- FACTOR MATRIX USING PRINCIPAL FACTOR, NO ITERATIONS
   0
         1146-
          1166-
   0
                               FACTOR 1 FACTOR 2
                                                       FACTOR 3
          1176=
          1180=
1190= FN
1280= AN
                                             .78577
-.16424
.74948
-.64983
-.43643
.27641
                                                           .56157
.56172
    0
                                 .75466
.45851
-.87157
          1216= CH
                                                          -.47047
          1229- FN
                                                           .21299
    O
                                 10538.
CANA:-
          1236- W
                                                            .25441
                                                           .42354
          1240- CR
```

```
1256=
      1268=
1278=
       1286=
       1296- VARIABLE
       :366=
       1316= FN
                             .99452
       1328: AN
                             .91232
       1336= CN
                             .99359
      1346= FN
1358= NM
                             .84277
C
                             .93961
       1360- CH
                             .88256
       1378-1FACTOR AMALYSIS
                                                                                PACE
                                                         63/22/82 15.41.26.
      1300=
1390= FILE - NOMANE (CREATED - #3/22/82)
       1466=
0
      1410=
      1428=
               QUARTIMAL ROTATED FACTOR MATRIX
      1436= AFTER ROTATION WITH KAISER NORMALIZATION
C
      1448=
      1456=
      1468=
C
      1478=
       1486=
                           FACTOR 1 FACTOR 2 FACTOR 3
      1496=
      1566: FN
                             .17585
                                         -.14866
                                                       .97158
      1516= AN
                             .91629
                                          .62946
                                                       .26816
                            -.13973
                                                       .42144
       1528= CN
                                         -.89244
                            -.66575
      1536: F#
                                          .68872
                                                      -.63883
                                                      -.11765
                              .95349
       1548= MM
                                         -.12661
       1556= CH
                            -.36216
                                          .71976
                                                       .48315
       1566=
      1576=
      1569=
\mathbf{C}
      1596=
      1686= TRANSFORMATION MATRIX
      1616=
C
       1629=
       :63#=
       1646=
C
       165#=
                           FACTOR 1
                                       FACTOR 2 FACTOR 3
       1666=
      1678= FACTOR 1
1688= FACTOR 2
                              .88496
                                         -.57935
                                                       .12962
C
                                                        .82721
                            -.48892
                                         -.38537
       1698= FACTOR 3
                              .42991
                                          .71822
                                                       .54711
       1796=1FACTOR AMALTSIS
                                                         63/22/82 15.41.26.
                                                                                 PACE
C
      1716=
       1728= FILE - NONAME (CREATED - #3/22/82)
      1736=
0
      1746=
1750= FACTOR SCORE COEFFICIENTS
1746=
      1779=
1786=
1796=
1796=
0
0
                           FACTOR 1 FACTOR 2 FACTOR 3
       1816=
      1828= FN
                              .65814
                                           .00342
0
      1836= AM
                                          .19064
                             .44948
                                                       .17973
      1848= CH
1858= FN
                            -.23210
                                         -.53192
                                                       .24299
                            -.17228
                                          .31593
                                                       .62126
Ó
                                          .80448
.41626
                                                      -.19942
.30446
      1946= 181
                             .44392
      1876= CH
                             -.#353
      1906-1FACTOR ANALYSIS
                                                         #3/22/82 15.41.24.
                                                                                 PACE
C
      1896=
```

```
19:8= CPU TIME REQUIRED.. .8948 SEC
19:28=
19:38=
19:46=
19:58= TOTAL CPU TIME USEB.. .1728 S
19:48=
19:78=
19:08=
19:08=
20:08= NUMBER OF CONTROL CARDS READ 21
20:38= NUMBER OF ERRORS DETECTED 6
20:58==60R
             1918- CPU TIME REQUIRED...
                                                                                                  .1726 SECONDS
0
\mathbf{C}
C
C
 0
C
```

```
166:1
       110=5
                                                     #3/22/82 15.18.55. PAGE :
       125=
                     VOCELBACK COMPUTING CENTER
       136=
       146=
                     NORTHWESTERN UNIVERSITY
(
       156=
       146-
                    S P S S - - STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES
       176=
G
       186=
                    VERSION 8.6 -- JUNE 18. 1979
      196=
266=
0
      216=
       225
       236= RIM NAME
                          FACTOR AMALTSIS
0
      248- VARIABLE LIST FTNT-FNZU-FRIM-FTOG-ATHT-ANZU-
       256=
                           AMIN. ATDG. CTUT. CNZU. CHIM. CTOG.
                           FF.MA.CC.FN.AN.CN.FH.MI.CH
       268=
       278= IMPUT FORMAT
C
                          FREEFIELD
       288= INPUT MEDIUM
                          DISK
       296= N OF CASES
                           UNKNOWN
C.
                           FF=FTNT/FTOG
       366= COMPUTE
       316= COMPUTE
                           AA=ATHT/ATOG
       328= COMPUTE
                           CC=CTWT/CTOG
(
       330= COMPUTE
                           FN=FNZU+FTHT
       346= COMPUTE
                           AN=ANZU-ATUT
       350= COMPUTE
                           CH=CNZU+CTHT
       368= COMPUTE
                           FH=FWZU/FHIN
       376= COMPUTE
                           MM=ANZU/ANIR
       386= COMPUTE
                           CM=CMZU/CMIM
       396= FACTOR
                           VARIABLES=FN.AN.CH/TYPE=PA1/
                           ROTATE - QUARTIMAI/
       466=
                           VARIABLES=FF.AA.CC/TYPE=PA1/
       41#=
                           ROTATE=QUARTIMAI/
\mathbf{C}
       424=
       434=
                           VARIABLES=FM.NM.CH/TYPE=PA1/
                           ROTATE=QUARTINAX/
       444:
C
                           VARIABLES=FN-AN+CN+FN+NH+CH/TYPE=PA1/
       456=
                           ROTATE=QUARTIMAL/
       468=
       478= OPTIONS
       496= STATISTICS
                           ALL
       498= READ IMPUT DATA
(
       516= 86653166 CM NEEDED FOR FACTOR
       524=
       536= END OF FILE ON FILE DAZ
O
                              & CASES FROM SUBFILE NOMANE
       540: AFTER READING
       558=1FACTOR ANALYSIS
                                                      63/22/62 15.18.55.
                                                                           PAGE 2
0
       578= FILE - NONAME (CREATED - 63/22/82)
       596-
686- VARIABLE
0
                                                         CASES
                               KEM
                                        STANDARD DEV
       415
       125- FB
                         24959.3758
                                           6182.7198
                         17567.1600
                                           9271.5718
       646= CH
                         53614.4866
                                          39944.1497
       450=1FACTOR AMALTSIS
                                                      $3/22/$2 15.18.55.
0
       679= FILE - NOMANE (CREATER - 03/22/02)
       696=
0
       700= CORNELATION COEFFICIENTS..
       716-
O
       725-
```

```
746=
  C
         756=
                                                    CN
         768=
         776= FN
                            1.50000
                                         .43666
                                                     .51375
  C
         796= MI
                              .43466
                                        1.00000
                                                    -.63792
                                                    1.00000
         798= CH
                                        -.63792
                              .51375
                                                      #3/22/82 15.18.55. PAGE 4
         BOS-IFACTOR AMALYSIS
- 🔽
         816=
         826= FILE - NOMANE (CREATED - 83/22/82)
  C
         844=
         854:
  0
         876= WARIABLE EST COMMENMALITY FACTOR EIGENVALUE PCT CUM PCT
         896:
896: FII
                                                 1.65541 55.2
                                                                 55.2
                                                 1.82741 34.6
  0
                           1.00000
                                                                89.8
                                          2
         916= CN
                                                  .36716 16.2 166.6
                                                      #3/22/82 15.18.55.
         928=1FACTOR AMALYSIS
                                                                            PACE 5
  C
         934:
         946= FILE - NONAME (CREATED - #3/22/82)
         958=
  Ċ
         96#=
         976= FACTOR MATRIX USING PRINCIPAL FACTOR, NO ITERATIONS
         986:
  C
         99#=
        1866=
        1616=
        1626=
                           FACTOR 1 FACTOR 2
        1836=
        1846= FN
                              .92228
                                         .66938
        1656= AN
                              .57343
                                         .77688
        1868: CN
                                        -.65862
                              .68976
        1676=
        1896=
        1896=
        11662
        1116= VARIABLE
                           COMMUNALITY
        1126=
        1136= FN
  C
                             .93259
        1146= AK
        115#= CN
                             .99955
                                                       63/22/82 15.18.55. PAGE 6
        1166=1FACTOR AMALTSIS
  0
        1176=
        1196= FILE - NOMAME | ICREATED - $3/22/82)
        1195=
  0
        1200=
        1216=
                QUARTINAL ROTATED FACTOR HATRIX
        1228- AFTER ROTATION WITH KAISER MORMALIZATION
  0
        1236=
        1240=
1230=
1256=
  0
        1270=
                           FACTOR 1 FACTOR 2
        1250
  0
                              .74235
                                         .54735
                              .61848
                                         .96565
        1316- CN
                              .14475
                                        -.13639
  0
        1328=
        1330-
       1340-
1356-
1366- TRANSFORMATION NATRIX
  0
        1379=
  C .1396-
1396-
```

```
:466=
(
                         FACTOR 1 FACTOR 2
     :4:0=
      1428:
      1436= FACTOR 1 .81686
1446= FACTOR 2 -.58523
                                       .58520
                                       .81884
      1458=1FACTOR ANALISIS
                                                    83/22/82 15.18.55. PAGE 7
      1468=
      1478= FILE - NOMAPE (CREATED - 83/22/82)
      1496=
1496=
C
      1500= FACTOR SCORE COEFFICIENTS
      1514=
      1526=
     1539=
1546=
1550=
                         FACTOR 1 FACTOR 2
      1560=
                                       .00008
      1576= FN
                           14647
      1588= AN
                          -.:5728
                                      .2:382
C
      1598= CN
                           .78941
                                      -.27894
      :686=
      1618= ERROR NUMBER.. 843. PROCESSING CEASES, ERROR SCAN CONTINUES.
Ċ
     1628=
      1636=
     1646= CPU TIME REQUIRED ...
                                    . SEAS SECONDS
      1650=
      1666=
     1679=
(
      1686:
              ---- ERROR SUMMARY ----
      1698=
      :788=
      1716=
      1726×
               ERROR NUMBER.. 843
      1736=
C
     1746=
               VARIABLE NAME ON SUBSEQUENT VARIABLES LIST IS NOT
      1756=
               INCLUDED IN THE FIRST VARIABLES LIST
      1764=
(
     1778: TOTAL CPU TIME USEB..
                                     .1788 SECONDS
     1784:
      1796=
C
     1966=
      181#=
      1826= RUN COMPLETED
C.
     1836=
     1846= NUMBER OF CONTROL CARDS READ 27
     1850: MUMBER OF ERRORS DETECTED
C
     1846=5
0
0
0
0
0
C
```

```
..D.131
  (
        ..L.A
  €.
         190=RUN NAME
                           FACTOR AMALYSIS
        116-VARIABLE LIST FTHT.FMZU.FMXH.FTGG.ATHT.AMZU
                          ANIM-ATOG.CTUT.CHZU-CHIM.CTOG
        128=
· <u>C</u>
                          FF.AA.CC.FN.AM.CN.FH.MM.CN
        122-
        146=IMPUT FORMAT
                          FREEFIELD
        150=IMPUT RECIUM
160=M OF CASES
                          EISK
  C
                          HAKACHA
        176-COMPUTE
                          FF=FTHT/FTOG
        196=COMPUTE
                          AA=ATHT/ATOC
  0
        196-COMPUTE
                          CC=CTWT/CTOC
                          FN=FNZU+FTWT
        200=COMPUTE
        216=COMPUTE
                          AN=ANZUSATHT
  0
        228=COMPUTE
                          CN=CNZU+CTWT
        236=COMPUTE
                          FM=FNZU/FHXM
        240=COMPUTE
                          NR=ANZU/ANZH
  C
        256=COMPUTE
                          CH=CNZU/CHXR
        268=FACTOR
                          VARIABLES: FTWT TO CTOC/TYPE:PA1/
                          ROTATE=QUARTINAT/
        276×
  (.
        286=
                          VARIABLES=FN.AN.CN/TYPE=PA1/
        298=
                          ROTATE=QUARTINAX/
        366=
                          VARIABLES=FF+AA+CC/TYPE=P41/
  (
        31#=
                          ROTATE=QUARTIMAI/
                          VARIABLES=FH.NM.CH/TYPE=PA1/
        32#=
                         ROTATE=QUARTINAS/
        334:
                          VARIABLES=FN:AN.CN:FN:NN:CH/TYPE=PA1/
        341=
        356=
                         NIANTTANUPESTATOR
        36#=OPTION
        378=STATISTICS
        388=READ INPUT DATA
       .. SAVE . FAZ . N . G
       ..REPLACE .FA2 . ID=B020
                        HAS BEEN REPLACED
       LE NAME FA2
       ..EDIT.DAZ.S
 \mathbf{C}
       ..L.A
 C
         188=2484 12,75 2,4 41916 3692 4,6 1,1 73886 33712 3,75 .86 769866 6 6 6 6 6 6 6 6
        O
        148=2186 9.8 .95 25866 1672 1.85 .93 20866 8797 3.9 .54 1242466 8 8 8 8 8 8 8 8 8
        156=2631 18.5 1.8 31276 2959 7.5 1.8 62953 3729 3.9 .53 55666 0 0 0 0 0 0
 0
       ..REWIND.SPSS.DA2.FA2
       ..FILES
       OCAL FILES --
       DAZ
                FA2
                         SCDOUT SIMPUT
                                           SOUTPUT
       ..SPSG.B-BA2, I=FA2,LO-ABRV.L=U1+NR
       PSS ERMON
       Colf 👾
 0
         100=1
        116-S
        126=
                                                   63/22/62 14.42.32. PAGE 1
        136=
                     VOCELBACK COMPUTING CENTER
        146=
                     MORTHMESTERN UNIVERSITY
        156
 0
        140=
                    S P S S - - STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES
```

```
156=INPUT MEDIUM
                           DISK
       166=N OF CASES
       176=CORPUTE
                            FF*FTWT/FTOG
       186=COMPUTE
                            AA-ATHT/ATOC
       199=COMPUTE
                            CC=CTNT/CTOC
                            FN=FNZU+FTUT
       296=COMPUTE
                            AN=MIZUAATUT
       216=COMPUTE
                            CN=CNZU4CTNT
       228=COMPUTE
       236=CONPUTE
                            FN=FNZU/FNIN
       246-COMPUTE
                            MM=ANZU/ANIN
       258=COMPUTE
                            CM=CMZU/CM1M
       271=FACTOR
                            VARIABLES=FN. NN. CH/TTPE=PAI/
                            ROTATE=QUARTIMAZ/
       296-
                            VARIABLES=FN-AN-CN-FH-NN-CH/TYPE=PA1/
       310=
                            ROTATE=QUARTIMAL/
       329-OPTIONS
330-STATISTICS
                            ALL
       346=READ INPUT DATA
      .. SAVE , FA1 . N . O
      ..RETURN.WI
      .. REWIND , SPSS , DAZ , FA1
      ..$P$$.D-
      D PARAMETER ON SPSS CALL
      SPSS ERRORS
      ..SPSS.B=DAZ.I=FA1.LO=ABRV.L=W1.NR
      PSS ERRORS
      ..EBIT.WI.S
(.
O
        LIA
         166=1
       116=5
       126=
                                                           #3/22/82 15.34.38. PAGE 1
        136=
                       VOCELBACK COMPUTING CENTER
       14#=
                       MORTHMESTERN UNIVERSITY
C
       156=
       148=
                       S P S S - - STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES
0
       190=
190=
200=
                       VERSION B.# -- JUNE 18, 1979
       ZNO- NOW MAKE FACTOR ANALYSIS
240- WARIABLE LIST FTET-FREN-FREN-FTOG-ATUT-ANEU-
                              AREM-ATOC.CTWT.CHZU.CREW.CTBC.
                             FF.AA.CC.FN.AM.CH.FN.MI.CR
        248
       276- IMPUT FORMAT
286- IMPUT HEDIUM
296- N OF CASES
                             MEFIELD
                             BISK
                             FF-FTVT/FT0G
0
       360- COMPUTE
310- COMPUTE
                             AA-ATHT/ATOC
        320- COMPUTE
                             CC=CTNT/CTOC
                             FIN-FILLUSFTILT
MI-MILLUSATUT
        330- COMPUTE
        346- COMPUTE
```

```
158= 10#FUTE
                             CN=CNZU+CTHT
         364: 30#P JTE
                             FR=FMZU/FMIR
         376= COMPUTE
                             MIN-AMTH/AMTR
         COMPUTE
                             CH=CNZU/CHIM
  C
         398: FACTOR
                             VARIABLES=FH:NM:CH/TYPE=PA1/
                             ROTATE=QUARTIMAE/
          466:
                             VARIABLES=FN-AN-CN-FN-MN-CN/TYPE=PA1/
          4:6=
. 🕻
          428=
                             ROTATE=QUARTIMAS/
          436= OPTIONS
          448= STATISTICS
   C
         456= READ INPUT DATA
          478= 86653166 CH NEEDED FOR FACTOR
         496= END OF FILE ON FILE DAZ
580= AFTER READING 6 CAS
                                 & CASES FROM SUBFILE NONAME
   0
         518=1FACTOR ANALYSIS
                                                        #3/22/82 15.34.3#. PAGE 2
          526=
          536= FILE - NOMANE (CREATED - 83/22/92)
   C
          544=
          556=
                                          STANDARD DEV
          566= VARIABLE
                                  MEAN
                                                           CASES
   (
          574=
          58#= F#
                               6.5272
                                                 2.7336
          598= NH
                               8.6154
                                                 7.1815
   (
          689= CM
                               5.7818
                                                1.25:7
          616=1FACTOR ANALYSIS
                                                        63/22/62 15.34.38.
                                                                               FAGE
          624=
          638= FILE - NONAME (CREATED - 83/22/82)
          644:
          656:
          668= CORRELATION COEFFICIENTS..
          67#=
          686=
          69#=
          706=
                                                      CH
          716=
   C
          729=
                             1.50000
                                                       .56838
                                          -.78119
          738= FH
                              -.75119
          744= NR
                                         1.54004
                                                      -.43399
   O
          756= CH
                                                      1.00000
                               .54838
                                          -.43399
                                                        $3/22/82 15.34.36. PAGE 4
          760=1FACTOR ANALYSIS
   O
          788= FILE - NONAME (CREATER - 63/22/82)
          798=
   0
          816=
          826=
          836= VARIABLE EST COMMUNALITY FACTOR EIGENVALUE PCT CUM PCT
         844:
850: FN
   0
                             1.00006
1.00006
1.00006
                                                   2.14271 71.4
                                                                   71.4
                                                    .58267 19.4 96.8
.27462 9.2 196.8
          M4= 10
                                            2
          E79= CH 1.
SMS=1FRCTOR AMALYSIS
                                                        #3/22/82 15.34.38.
                                                                               PACE 5
   0
          986= FILE - NOMME (CREATER - 83/22/82)
   0
          936- FACTOR MATRIX USING PRINCIPAL FACTOR, NO ITERATIONS
   0
          968=
          176-
                             FACTOR 1
   C
          998-
         1000= FH
```

```
الله عقى أور
                           -.65241
      .303= 09
                           .77366
      :836*
      :840=
      1656:
      :565=
      1878: VARIABLE
                         COMPUNALITY
     1686=
      1898: FH
                           .82159
     1100= Wi
                           .72255
     1118= CH
                           .59856
     1126=
     1136=
     1148= NUMBER OF FACTORS IS LESS THAN THE
      1150= PROCESSING CONTINUES BYPASSING ROTATION
     1166=
0
     1178=1FACTOR AMALYSIS
                                                     #3/22/82 15.34.3#. PAGE 6
      1186=
     1198= FILE - NOMARE (CREATED - 83/22/82)
     1266=
     121#=
      1226= FACTOR SCORE COEFFICIENTS
      1236=
      1246=
      1256=
      1266=
                         FACTOR 1
      1276=
      128#=
      1296= FH
                            .42362
                           -.39671
      1366= NH
      1316= CM
                            .36187
      :328=
      1336: ERROR NUMBER.. 843. PROCESSING CEASES, ERROR SCAN CONTINUES.
     1346=
     135#=
     1368= CPU TIME REQUIRED ..
                                    .8438 SECONDS
     1376=
     1386=
      1396:
      [466=
      1416=
               ---- ERROR SUMMARY -----
      1425=
      1438=
      1446=
      1456=
               ERROR NUMBER.. 843
               VARIABLE NAME ON SUBSEQUENT VARIABLES LIST IS NOT
      1463=
•
      1476=
                INCLUDED IN THE FIRST VARIABLES LIST
      1486=
      1498= TOTAL CPU TIME USED ...
                                      .1428 SECONDS
C
      1500=
      1516=
      1525=
      1536=
      1500- MIN COMPLETED
      1550
     1568= NUMBER OF CONTROL CAMPS READ 23
1578= NUMBER OF ERRORS DETECTED 1
     1500±5
0
0
(
```

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